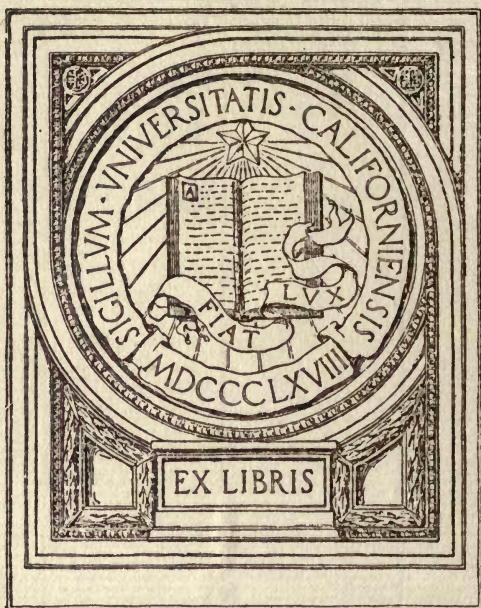


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UNIVERSITY OF WISCONSIN STUDIES *in science*
IN SCIENCE
NUMBER 3

THE DISTRIBUTION AND FOOD OF
THE FISHES OF THREE WISCONSIN
LAKES IN SUMMER

BY

A. S. PEARSE
PROFESSOR OF ZOOLOGY

MADISON

1921

UNIVERSITY OF WISCONSIN STUDIES

NUMBER 17
JUNE, 1921

SCIENCE NO. 3
PRICE, FIFTY CENTS

Published bi-monthly by the University of Wisconsin at Madison, Wisconsin

Entered as second class matter August 31, 1919 at the postoffice at Madison, Wisconsin, under the Act of August 24, 1912. Accepted for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917. Authorized September 17, 1918.

- No. 1. The Fishes of Lake Valencia, Venezuela, by A. S. Pearse. 52 p. Fifty cents.
- No. 2. Papers on Bacteriology and Allied Subjects, by Former Students of Harry Luman Russell. 200 p. \$1.00.
- No. 3. The Distribution and Food of the Fishes of Three Wisconsin Lakes in Summer, by A. S. Pearse. 60 p. Fifty cents.

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THE DISTRIBUTION AND FOOD OF THE FISHES OF THREE WISCONSIN LAKES IN SUMMER

INTRODUCTION

Except for the "reconnaissance" of Reighard (1915), little has been published on the ecology of lake fishes. For several years the writer has been studying the distribution, food, and parasites of the fishes in Wisconsin lakes. In 1916 routine catches were made in Lake Wingra, which is small and shallow (Pearse and Achtenberg, 1920). During the summer of 1919 the fishes in Green Lake and Lake Mendota were investigated (Pearse, 1920). The former lake is remarkable for its depth and clearness, the latter for the stagnation of its deeper parts during the summer. In 1920 work was done on three lakes:—Lake Pepin, which is a part of the Mississippi River and yet shows typical lacustrine conditions; Lake Michigan, representative of primitive lake habitats for the St. Lawrence drainage; and Lake Geneva, the clearest and deepest lake on the Mississippi drainage.

The study of the ecology of the Wisconsin lake fishes has progressed to such a stage that it is now possible to compare the fishes in six different types of lakes. Though this paper deals primarily with the three lakes studied during 1920, it also makes comparisons between all the lakes investigated, and thus gives a general summary of the work. Table I contains data relating to all the lakes considered. The lakes are arranged according to the total volume of water.

During the summer of 1920 the three lakes studied were under observation as follows: At Lake Pepin from June 20 to July 25 headquarters were made in a shanty owned by Mr. Jean Hogue on a sandy point extending between the Mississippi River and the slews north of the mouth of the Chippewa River. This location was close to the deepest parts of the lake. On Lake Michigan headquarters were in Mr. A. C. Kalmbach's fish market, Sturgeon Bay, from July 17 to 27. Three trips

were made out into Lake Michigan with commercial fishermen and seven days were spent fishing in Sturgeon Bay. From July 29 to August 7 the writer lived in a shanty owned by Mr. Andrew Nelson at Little Harbor, on Green Bay. At Lake Geneva quarters were made in the Yerkes Observatory from August 8 to 25. Fishing was done at the deepest points in the lake and alongshore from Fontana to the head of Williams Bay.

It is a pleasure to acknowledge the help received from various sources during the work. The United States Bureau of Fisheries identified several species of shiners and furnished funds to carry on the work. Mr. George Wagner named certain ciscoes. Mr. C. Juday, of the Wisconsin Geological and Natural History Survey, loaned a deep sea thermometer. The following persons extended various courtesies while work was being done in their localities: J. C. Broatch and Earle Little, Pepin, Wis.; A. C. Kalmbach and Andrew Nelson, Sturgeon Bay, Wis.; Mr. E. B. Frost and his colleagues in the Yerkes Observatory. Mr. Leslie Tasche did good work as assistant in the field, and Miss Marion E. Lamont was a valuable aid in the laboratory.

DISTRIBUTION OF THE FISHES

As the methods used for catching fishes and studying their distribution were the same as those described in a previous paper (Pearse, 1920), they will not be discussed in detail. Gill nets, all of which measured 4 by 75 feet, were set at various depths. As a rule a "battery" of five nets having meshes of $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2, and 3 inches respectively was set each morning and left without being disturbed for twenty-four hours. The seine used was fifty feet long and four feet deep; mesh, one quarter inch; with a bag, 4 by 4 feet, in the center. Trot lines were usually set at dusk and taken up early in the morning. The catches were made with the same apparatus in the various lakes and the methods were as similar as it was possible to make them. It is therefore proper to compare the data from the different lakes directly. Though all the lakes were studied during the summer, they were not studied simultaneously. The errors due to season or to peculiar conditions in certain years are believed to be negligible in influencing the general conclusions.

DISTRIBUTION OF FISHES IN LAKE PEPIN

Table II shows the catch per hour in gill nets at various depths. The greatest variety of species was caught in the upper five meters of the lake, but the highest catch per hour came from depths of 10 to 15 meters. As regards number of species the catches were: 0-5 meters, 13; 5-10 meters, 6; 10-15

TABLE I
COMPARISON OF SIX WISCONSIN LAKES

Lake	Volume, cu. meters	Depth, meters	Surface sq. km.	Temperature, summer	Clearness*
Wingra	2,761,000	4.3	2.2	26.8-26.8°C	.....
Geneva	434,773,000	43.3	22.1	7.3-23.6°C	4-5m. (7)
Mendota	478,370,000	25.6	39.4	9.7-23.3°C	2-3m.
Pepin	594,350,000	17.1	65.0	23.7-26.4°C	.....
Green	984,825,000	72.2	29.7	4.9-21.6°C	3-4,6m. (6)
Michigan	1,156,212,537,576	270.0	36129.6	(10.6) -19.7°C†	.....

* The figures in this column were supplied by Mr. C. Juday. They are approximate figures from readings with a 10 cm. Secchi disc and indicate the depth at which the disc disappeared from view.

† At a depth of twenty-four meters. Ward (1896) found 4°C. below 120 meters.

TABLE II
LAKE PEPIN. AVERAGE CATCH PER HOUR IN GILL NETS, JUNE 20 TO JULY 25, 1920

Mesh in inches	Depth in meters	No. hours nets were set	<i>Ameiurus melas</i>	<i>Carpoides carpio</i>	<i>Carpoides thompsoni</i>	<i>Cyprinus carpio</i>	<i>Esox lucius</i>	<i>Lepisosteus punctatus</i>	<i>Lepisosteus ossens</i>	<i>Microstoma antennatum</i>	<i>Microstoma breviceps</i>	<i>Perca flavescens</i>	<i>Roccus chrysops</i>	<i>Scaphyrhynchus platyrhynchus</i>	<i>Sitostedion canadense</i>	Total Fishes	Crayfishes	Clams
¾	0-5	151.4	.....	.....	.....	.....	.007	.....	.....	.....	.....	.073	.....	.007	.039	.126	.....	.....
	5-10	45.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.044	.....	.....	.109	.109	.....	.044
	10-15	22.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.044	.....	.....
	15-20	46.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.021	.....	.021	.043	.....
1	0-5	200.7	.....	.....	.....	.010	.070	.005	.005	.005	.005	.209	.005	.....	.114	.428	.....	.....
	5-10	90.8	.....	.....	.....	.....	.....	.....	.011	.....	.....	.011	.....	.011	.165	.198	.....	.011
	10-15	23.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.211	.211	.....	.....
	15-20	68.8	.....	.....	.....	.....	.....	.015	.....	.....	.....	.....	.....	.....	.073	.088	.....	.015
1½	0-5	201.1	.....	.....	.....	.....	.020	.005	.005	.....	.070	.015	.....	.005	.005	.125	.....	.....
	5-10	68.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.058	.058	.....	.030
	10-15	45.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.395	.088	.483	.....	.....
	15-20	69.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.158	.043	.201	.....	.....
2	0-5	177.7	.....	.....	.....	.011	.006	.....	.....	.017	.023	.....	.....	.....	.006	.063	.....	.....
	5-10	68.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	10-15	46.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.043	.....	.043	.....	.....
	15-20	69.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.245	.....	.245	.....	.....
3	0-5	201.8	.005	.005	.005	.005	.....	.....	.....	.087	.....	.....	.....	.....	.....	.020	.....	.005
	5-10	69.3	.....	.....	.001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.088	.....	.....
	10-15	46.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	15-20	69.8	.....	.....	.....	.001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.001	.....	.....
All	0-5	932.7	.005	.005	.005	.026	.103	.010	.010	.022	.098	.296	.005	.012	.164	.763	.....	.005
	5-10	343.3	.....	.....	.001	.....	.....	.....	.011	.087	.....	.011	.....	.011	.332	.453	.....	.085
	10-15	184.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.044	.....	.438	.299	.781	.....	.....
	15-20	324.2	.....	.....	.....	.001	.....	.015	.....	.....	.....	.....	.....	.424	.116	.558	.043	.015
Total	.....	1784.8	.005	.005	.006	.027	.103	.025	.021	.100	.008	.251	.005	.005	.254	.....	.....	.....

meters, 3; 15–20 meters, 4. These results of course leave out of consideration the fishes which are too small to be caught in gill nets. These would increase the number of species and individuals in shallow water. The results do indicate the distribution of the commoner, large fishes.

The black bullhead, pickerel, short-headed red-horse, and white bass were not caught below five meters. The lake carp, long-nosed gar, and white-nosed red-horse ranged down to ten meters. The perch extended to fifteen. The carp and channel cat were caught in the deepest and shallowest zone—where there was the most mud—but were not taken in intermediate waters. The “hackleback,” or sand sturgeon, was more abundant in deeper water and the sauger was most abundant at intermediate depths. Only four species of large fishes commonly take advantage of the food supplies in deep water. Clams were somewhat more abundant at greater depths and crayfishes were only caught in deep water.

These generalizations are intended to apply only to the summer season. The distribution of many fishes is doubtless quite different in winter. Furthermore, there are fishes in the lake (like the spoonbill, black bass, yellow bass, wall-eyed pike, mooneye, and skipjack), which were never caught in gill nets, and hence their distribution is more or less unknown.

Arranged according to their abundance as judged by the catch per hour in gill nets, the fishes in Lake Pepin rank in the following order:—sauger, .911; hackleback, .855; yellow perch, .351; white-nosed red-horse, .109; pickerel, .103; short-headed red-horse, .098; carp, .027; channel cat, .025; long-nosed gar, .021; lake carp, .006; black bullhead, .005; white bass, .005.

The fifty foot minnow seine was hauled in eight different localities on different days in Lake Pepin, the total length of all the hauls being about 1546 meters. Twenty-three species of fishes were caught. In the following summary of the catches, the first figure indicates the number of times a species was caught and the second, the total number of individuals caught:

<i>Percina caprodes</i> , log perch.....	8	625
<i>Notropis jejunus</i> , shiner.....	6	270
<i>Notropis atherinoides</i> , shiner.....	2	250
<i>Stizostedion</i> sp.?, young pike.....	7	156
<i>Perca flavescens</i> , yellow perch.....	4	133

<i>Notropis hudsonius</i> , shiner.....	6	108
<i>Micropterus salmoides</i> , largemouth black bass.....	6	100
<i>Lepomis incisor</i> , bluegill.....	2	62
<i>Micropterus dolomieu</i> , smallmouth black bass.....	4	32
<i>Hiodon tergisus</i> , mooneye.....	3	17
<i>Pomoxis annularis</i> , white crappie.....	1	15
<i>Esox lucius</i> , pickerel.....	5	14
<i>Catostomus commersonii</i> , common sucker.....	2	9
<i>Roccus chrysops</i> , white bass.....	1	6
<i>Aphredoderus sayanus</i> , pirate perch.....	1	5
<i>Boleosoma nigrum</i> , Johnny darter.....	3	5
<i>Pomoxis spatoides</i> , black crappie.....	2	4
<i>Cyprinus carpio</i> , carp.....	3	4
<i>Carpoides thompsoni</i> , river carp.....	2	4
<i>Schilbeades gyrimus</i> , tadpole cat.....	2	3
<i>Moxostoma breviceps</i> , short-headed red-horse.....	1	2
<i>Notropis heterodon</i> , shiner.....	2	2
<i>Ameiurus natalis</i> , yellow bullhead.....	1	1

Data on catches made with trot lines set in the slews at the foot of Lake Pepin were obtained from two sources. From June 26 to 30 Mr. Jean Hogue, a commercial fisherman, set a line. For bait he used minnows and "cut bait" from fishes. On four out of the five nights with 1125 5/0 Kirby hooks set for a total of about sixty hours he caught ten channel cats. Mr. Tasche set a total of 658 2/0 Kirby hooks on ten nights from July 1 to 13. With minnows, crayfishes, and "cut bait" he caught fishes and turtles as follows, the first figure indicating the number of nights a species was caught and the second, the total catch:

<i>Ameiurus natalis</i> , yellow bullhead.....	6	29
<i>Ictalurus punctatus</i> , channel cat.....	5	9
<i>Ameiurus melas</i> , black bullhead.....	2	5
<i>Ameiurus nebulosus</i> , speckled bullhead.....	2	3
<i>Anguilla crysypa</i> , eel.....	1	1
<i>Lepisosteus platostomus</i> , duck-billed gar.....	1	1
<i>Chrysemys marginata</i> , painted turtle.....	1	1
<i>Emydoidea blandingi</i> , Blanding's turtle.....	1	1
<i>Platypeltis spinifera</i> , soft-shelled turtle.....	1	1

Information as to the abundance and distribution of the fishes in Lake Pepin was also obtained from Mr. Earle Little and his crew. These men operated a commercial seine just above the outlet of the lake. The seine was 2,000 feet long and 28 feet deep; the mesh was 2½ inch, bar measure, except

150 feet in the center, which was 2 inch. On being questioned the four seiners agreed that from June 15 to November 15 their catch per day would average about as follows:

Carp, <i>Cyprinus carpio</i> and <i>Carpoides</i> , two or three species. . . .	500 lbs.
Dogfish, <i>Amia calva</i> (1000 lbs. on some days in autumn)	400 "
Sheepshead, <i>Aplodinotus grunniens</i>	350 "
Suckers and red-horses, <i>Moxostoma</i> ; <i>Calostomus</i>	200 "
Wall-eyed pike, <i>Stizostedion vitreum</i>	200 "
Mooneye, <i>Hiodon tergisus</i>	100 "
Pickrel, <i>Esox lucius</i> (catch greater in autumn)	50 "
Buffalo, <i>Ictiobus</i> , three or four species	25 "
Spoonbill, <i>Polyodon spathula</i>	25 "
Catfishes and bullheads, <i>Leplopus olivaris</i> ; <i>Ictalurus punctatus</i> ; <i>Ameiurus</i> (catch greater in autumn)	25 "
White bass, <i>Roccus chrysops</i>	10 "
Black bass, <i>Micropterus</i> , 2 species	10 "
Bluegill, <i>Lepomis incisor</i>	1 lb.
Crappies, <i>Pomoxis</i>	1 "

While the writer was at Lake Pepin, the crew never seined where the water was more than seven or eight meters deep. When the water is low in the autumn, however, the fishermen haul from the deepest part of the lake (17 m.).

On two days fishing was carried on with hook and line, and once with a trot line, in two coulees about a mile above the outlet of Lake Pepin on the Minnesota side. The coulees are little drainage basins with ponds at their bottoms. The ponds are connected with the lake under the C. M. & St. P. R.R. bridges. Their borders are grown up with willows and they are filled with aquatic vegetation.

On June 6, fishing from 2:00 to 5:00 p. m. with three hooks baited with earthworms and grasshoppers, a largemouth black bass, a smallmouth blackbass, two bluegills, and a pumpkinseed were caught. On July 8 from 9:45 A. M. to 12:00 M. fishing with three hooks baited with worms the following fishes were caught: 6 pumpkinseeds, 1 yellow bullhead, 1 carp, 1 bluegill. A trot-line bearing seventy 2/0 Kirby hooks baited with earthworms was also set from 9:30 A. M. to 11:00 A. M. It caught 3 carp and 1 pumpkinseed.

Forty-six species of fishes were examined from Lake Pepin and from the slews near its outlet. Wagner (1908) records forty-three species from the lake. The following ten species

noted by him were not observed by the writer during the summer of 1920:—*Acipenser rubicundus*, *Ambloplites rupestris*, *Apomotis cyanellus*, *Hadropterus guentheri*, *Hybopsis storerianus*, *Lota maculosa*, *Moxostoma aureolum*, *Notropis blennioides*, *Notropis rubifrons*, *Notropis whipplei*. The following thirteen species not recorded by Wagner were taken by the writer: *Aphredoderus sayanus*, *Ameiurus melas*, *Ameiurus natalis*, *Ameiurus nebulosus*, *Carpoides carpio*, *Carpoides thompsoni*, *Eupomotis gibbosus*, *Morone interrupta*, *Moxostoma breviceps*, *Notropis jejunus*, *Notropis atherinoides*, *Notropis heterodon*, *Pomoxis annularis*. A complete list of all the species examined is given under the section on food (pp. 29–39).

Marked changes have evidently occurred in the fish fauna of the lake since Wagner (1908) made his observations in 1903 and 1904. The lamprey eel is no longer common probably because its usual host, the spoonbill, has decreased in numbers. Wagner says (p. 27), "the spoonbill is one of the most abundant forms in Lake Pepin throughout the summer." In 1920 this species was rather uncommon. Again Wagner says that the rock sturgeon is "not uncommon," and that the hackleback is rare. In 1920 (Table II) the hackleback was abundant and the rock sturgeon (not seen by the writer) very rare. Wagner took no bullheads, except the tadpole cat. Three species were common in 1920. The buffalo (*Ictiobus cyprinella*) was "very abundant," and is now rather uncommon. It has been replaced by the carp, which in 1920 led all other species in commercial value. Wagner found the skipjack "very common" and in 1920 it was quite rare. He found the rock bass very common and the young were "extraordinarily numerous alongshore." In 1920 no rock bass were caught, although special efforts were made. The local fisherman all agreed that it was an exceedingly rare fish. The perch was rare in 1904 and in 1920 was rather common. Small largemouth black bass are no longer so abundant alongshore as to be a "nuisance in fishing with a minnow seine."

The spoonbill, rock sturgeon, and buffalo have evidently been more or less "fished out" during the past fifteen years and the last has been replaced by the carp, which has similar habits. Wagner probably took no bullheads because he did not fish with trot-lines. The writer sees no apparent reason for the marked decrease of the skipjack and rock bass.

Considering all the evidence, the following peculiarities may be pointed out regarding the fish fauna of Lake Pepin, which differs from other deep Wisconsin lakes studied in its intimate association with a great river, its turbidity, and its lack of marked thermal stratification in summer. In deep water the hackleback sturgeon is the most abundant fish during the summer and the yellow perch is rare or absent. In winter dogfish, carp, wall-eyed pike and other fishes frequent the deep water. The log perch is the dominant small fish alongshore. There are many species present in numbers which are not typical lake fishes but ecologically belong in rivers—i.e., quillbacks and river carp, mooneye, channel cat, buffaloes, red-horses, spoonbill, skipjack, sauger, hackleback, etc. The greatest number of species and individuals is found in the shallowest water, the population of the five meters just below the surface exceeding that of any other five-meter zone, except that of the zone from 10 to 15 meters where the deep and shallow water fishes overlap.

DISTRIBUTION OF FISHES IN LAKE MICHIGAN

The shores of Lake Michigan in the region of Sturgeon Bay and the Sturgeon Bay Canal are rocky or sandy and the shores in the Bay itself are sandy. At the head of the Bay there are several large patches of rushes (*Scirpus*) and a couple of small swampy areas. Table III gives the catch per hour in the writer's gill nets at various depths. The greatest variety of species was caught in the first five meters below the surface, but the largest number of individuals was caught at depths of 5 to 10 meters. The number of species caught in each stratum was as follows: 0-5 m., 7; 5-10 m., 4; 10-15 m., 1; 15-20 m., 3; 25-30 m., 2. The black bullhead, carp, and pumpkinseed do not range below five meters; the rock bass and pickerel extend from the surface down to ten; the common sucker, to twenty; and the yellow perch, to thirty. The bloater is found only in deep water, below fifteen meters.

Arranged according to their abundance as judged by the catch per hour in the writer's gill nets, the fishes in Lake Michigan rank in the following order: yellow perch, 2.538; pickerel, .265; bloater, .107; rock bass, .053; common sucker, .053; black bullhead, .036; pumpkinseed, .021; carp, .012. Only

TABLE III—Continued
LAKE MICHIGAN. AVERAGE CATCH PER HOUR IN GILL NETS, JULY 20 TO AUGUST 6, 1920

Mesh in inches	Depth in meters	No. hours nets were set	<i>Ambloplites rupestris</i>	<i>Ameiurus melas</i>	<i>Calostomus commersoni</i>	<i>Cyprinus carpio</i>	<i>Esox lucius</i>	<i>Eubomolis gibbosus</i>	<i>Leucichthys kareghus</i>	<i>Perca flavescens</i>	Total Fishes	<i>Chrysemys mdrigiana</i>	<i>Camburus virilis</i>
2	0-5	84.6	.....	.....	.012	.012	.071	.....	.....	.....	.095	.....	.....
	5-10	103.4	.....	.....	.010	.....	.019	.....	.....	.....	.029	.....	.....
	10-15	35.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	15-20	23.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	20-25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25-30	45.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	0-5	84.4	.....	.....	.....	.....	.012	.....	.....	.....	.012	.....	.....
	5-10	103.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	10-15	35.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	15-20	23.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	20-25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25-30	46.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
All	0-5	433.3	.024	.036	.060	.012	.188	.021	.....	.466	.807	.012	.021
	5-10	517.3	.029	.012	.029	.....	.077	.....	.....	.952	1.087	.....	.076
	10-15	118.2	.....	.....	.....	.....	.....	.....	.....	.261	.261	.....	.....
	15-20	166.1	.....	.....	.064	.....	.....	.....	.021	.794	.879	.....	.....
	20-25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25-30	230.1	.....	.....	.....	.....	.....	.....	.086	.065	.151	.....	.022
Total....	0-30	1465.0	.053	.048	.153	.012	.265	.021	.107	2.538	3.185	.012	.119

eight species were caught in the nets as compared to thirteen caught in Lake Pepin.

The writer made three trips on Lake Michigan with the boats "Albert C. Kalmbach" and "Four Brothers." The gill nets used by the crews were about eight feet deep and the meshes were $2\frac{1}{4}$ inch or $1\frac{5}{16}$ inch, "bar mesh." On July 22, 1600 feet of $2\frac{1}{4}$ inch mesh net was hauled from 15 to 30 fathoms, where it had been set for four days. On July 26, 1600 feet of $1\frac{5}{16}$ inch mesh net was hauled from 65 to 80 fathoms off Bayley's Harbor where it had been set seven days. On July 27, 3200 feet of $2\frac{1}{4}$ inch mesh net was lifted from 15 to 35 fathoms where it had been for four days. The catches on these days have been figured to the same catch-per-hour basis as that for a gill net seventy-five feet long in order that they may be compared with the catches of the writer's nets in shallower water. They are summarized in Table IV.

It will be noted that the catch per hour for the bloater caught by the writer (*Leucichthys harengus*) was somewhat less (Table III) than that (*L. hoyi*) of the deep water fisherman (Table IV). The other species caught in deep water were not taken in any of the writer's nets down to 28.5 meters. The long-nosed sucker, whitefish, and longjaw were caught in $2\frac{1}{4}$ inch mesh nets at depths of from 27 to 64 meters, but were not taken in $1\frac{5}{16}$ inch mesh nets set from 119 to 146 meters. The opposite is true of the blackfin and cottid. The cottid was probably not taken at depths of 27 to 64 meters because the mesh of the nets set was too large, as it was found in the stomachs of other fishes. The

TABLE IV

LAKE MICHIGAN. CATCH PER HOUR IN GILL NETS SET IN DEEP WATER BY COMMERCIAL FISHERMEN, ON THE BASIS OF A NET 75 FEET LONG

Mesh of nets in inches.....	$2\frac{1}{4}$	$1\frac{5}{16}$
Depth in meters.....	27-64	119-146
No. hours nets were set.....	192	166
<i>Catostomus catostomus</i>	.00074	.....
<i>Coregonus clupeaformis</i>	.00043	.....
<i>Cristivomer namaycush</i>	.02531	.01568
<i>Leucichthys johannae</i>	.00030	.00470
<i>Leucichthys hoyi</i>	.05069	.00628
<i>Leucichthys nigripinnis</i>.....	.....	.000063
<i>Leucichthys prognathus</i>	.00014	.....
<i>Lota maculosa</i>	.00333	.00038
<i>Uranidea kumlienii</i>.....	.....	.000157
Total.....	.08094	.02734

blackfin and long jaw are rare ciscoes and the catch is not to be taken as an accurate measure of relative abundance. For the other fishes, however, the catch-per-hour may be looked upon as giving data which shows the relative number of each species present. In order of abundance the deep water fishes rank in the following order: bloater (*L. hoyi*), lake trout, lawyer, long-nosed sucker, chub (*L. johannae*), whitefish, cottid, longjaw (*L. prognathus*), blackfin (*L. nigripinnis*).

In Sturgeon Bay and at Little Harbor a trot line was set on seven nights. The catch figured as for a total of 648 2/0 Kirby hooks set overnight was *Ameiurus melas*, 2; *Ameiurus natalis*, 1; *Ameiurus nebulosus*, 3; *Perca flavescens*, 18; *Necturus maculosus*, 1. Arranged in order of abundance as judged by total catch on trot lines the order is as follows; the first figure indicating the number of nights when a species was caught and the second the total number caught: yellow perch, 5-18; speckled bullhead, 2-3; black bullhead, 2-2; yellow bullhead, 1-1; mud puppy, 1-1.

With the seine three hauls were made for a total of about 711 meters. The species caught and the number of each was as follows, the first figure indicating the number of times caught and the second the total number: *Pimephales notatus*, 2-850; *Notropis hudsonius*, 3-175; *Perca flavescens*, 2-58; *Micropterus dolomieu*, 1-51; *Etheostoma iowæ*, 2-11; *Notemigonus crysoleucas*, 1-10; *Micropterus salmoides*, 1-10; *Boleosoma nigrum*, 2-6; *Catostomus commersonii*, 2-3; *Ameiurus nebulosus*, 1-2; *Eupomotis gibbosus*, 1-1; *Fundulus diaphanus menona*, 1-1; *Percina caprodes*, 1-1.

All things considered the following statements in regard to the fish fauna of Lake Michigan in the Sturgeon Bay region appear to be justified. In shallow water alongshore the yellow perch is the characteristic and most abundant fish. The pickerel is next in abundance and the rock bass is quite common. There are very few small fishes. In sheltered bays there are Iowa and Johnny darters, black bass, a few shiners and bluntnosed minnows. On and near swampy shores there are bullheads, a few pumpkinseeds, and an occasional carp or dogfish. The dominant fishes in the depths of the lake are ciscoes and lake trout. The lawyer and cottid, and long-nosed sucker are also fairly common. The whitefish is rather rare.

DISTRIBUTION OF FISHES IN LAKE GENEVA

Lake Geneva is the clearest of the lakes studied in Wisconsin (Table I). Its shores are for the most part rocky and steep. There is comparatively little aquatic vegetation.

Table V gives the results of catches with gill nets at various depths in Lake Geneva. Of the eleven species caught, six did not extend below a depth of fifteen meters: common sucker, pickerel, pumpkinseed, bluegill, largemouth black bass, brook trout. The rock bass and wall-eyed pike ranged down to 20 meters; the smallmouth bass to 25 meters; and the perch to 35 meters. The cisco was caught at depths of 15 to 25 meters. It will be noted that there were twice as many fishes caught from five to ten meters below the surface as were caught between the surface and a depth of five meters. There are probably a number of factors contributing to this peculiarity in distribution, but doubtless it is due chiefly to the rocky shores and the clearness of the water. The rocks make it difficult for plants to gain a foothold, and the clearness of the water makes it possible for plants, which are much frequented by fishes, to grow at greater depths.

Judged by the catch per hour in gill nets the abundance of the eleven species was as follows: *Perca flavescens*, .977; *Ambloplites rupestris*, .781; *Micropterus dolomieu*, .589; *Leucichthys artedisco*, .279; *Stizostedion vitreum*, .252; *Catostomus commersonii*, .171; *Esox lucius*, .129; *Eupomotis gibbosus*, .058; *Lepomis incisor*, .022; *Micropterus salmoides*, .010; *Salvelinus fontinalis*, .009.

The absence of fishes in deep water is doubtless due to lack of oxygen. Birge and Juday (1911, p. 148) on September 25, 1906 found about .5 c.c. or less of oxygen per liter below 30 meters, and (p. 230) that there was little plankton in the deeper water. There is no doubt that there was a lack of oxygen in the deeper water while the writer was fishing in Lake Geneva during August, 1920.

A trot line was set on six nights in favorable places along the shores of Lake Geneva. A total of 504 2/0 Kirby hooks caught one rock bass.

Nine hauls were made with the seine over a total of about 1,940 meters of shore. The following fishes were caught, the

first figure indicating the number of times each species was caught and the second, the total number caught: *Perca flavescens*, 8-3155;¹ *Micropterus salmoides*, 7-230; *Micropterus dolomieu*, 6-223; *Lepomis incisor*, 6-59; *Notropis hudsonius*, 4-30; *Ambloplites rupestris*, 3-17; *Eupomotis gibbosus*, 5-15; *Catostomus commersonii*, 3-8.

From all sources of information the following statements regarding the fish fauna of Lake Geneva appear to be justified. There are fewer species of fishes than in any other lake studied. This is probably due to the lack of variety in the shore habitats. The dominant large fishes are yellow perch, smallmouth black bass, rock bass, pickerel, suckers and wall-eyed pike. There are a small number of bluegills, largemouth black bass, and trout. Ciscoes are found at depths of 15 to 25 meters in summer—above the region of stagnation and in fairly cool water. Though there appear to be many young largemouth black bass in the lake there are few adults. There are very few shiners. No darters were caught, although special search was made for them. Bullheads, gars, and carp are rare in the lake, and none were caught by the writer.

DISCUSSION OF DISTRIBUTION OF FISHES IN ALL LAKES

The six lakes studied rank in the following order (Table VIII) according to the total catch per hour in gill nets: Wingra 7.703, Mendota 5.050, Green 3.677, Geneva 3.285, Michigan 3.280, Pepin 2.553.

Lake Wingra is the smallest and shallowest of the lakes and its shores are everywhere of soft mud. That it contains more fish per unit area than any other lake, is due to the yellow perch, which though small in size occurs in great numbers. Other abundant species are the largemouth black bass, pumpkinseed, bream, crappie, and bluegill. All these fishes, except the perch, are seldom found except where there is aquatic vegetation.

Lake Mendota is deep and has rather varied shores. A couple of small rivers run into it. Its deeper water is stagnant for about three months in summer. This lake is also dominated by the yellow perch, which is abundant in deep water when it is not stagnant and also very numerous inshore. Much less com-

¹ The number of individuals is very large because 2,800 were caught on one occasion from a large school off the mouth of a little stream at Fontana.

TABLE V—Continued
LAKE GENEVA. AVERAGE CATCH PER HOUR IN GILL NETS, AUGUST 8 TO 25, 1920

Mesh in inches	Depth in meters	No. hours nets were set	<i>Ambloplites rupestris</i>	<i>Castionomus commersoni</i>	<i>Esox lucius</i>	<i>Rapomotis gibbosus</i>	<i>Lepomis incisor</i>	<i>Leucichthys arctidisco</i>	<i>Micropterus dolomieu</i>	<i>Micropterus salmoides</i>	<i>Perca flavescens</i>	<i>Salvelinus fontinalis</i>	<i>Stizostedion vitreum</i>	Total Fishes	<i>Camburus virilis</i>
2	0-5	45.5	.044	...	.044	...	...	...	.022	...	...	...	...	.110	...
	5-10	45.5	.132	.022	.022	...	.022	...	.132	...	...	...	...	.330	...
	10-15	71.1	...	...	.014	...	...	...	...	...	...	...	...	.014	...
	15-20	45.5	...	...	...	...	...	...	...	...	...	...	...	...	...
	20-25	44.7	...	...	...	...	...	...	.014	...	...	...	...	.014	...
	30-35	48.6	...	...	...	...	...	...	...	...	...	...	...	...	...
3	0-5	45.9	...	...	...	...	...	...	...	...	...	...	...	...	...
	5-10	46.9	...	...	...	...	...	...	...	...	...	...	...	...	...
	10-15	42.0	...	...	...	...	...	...	...	...	...	...	...	...	...
	15-20	89.1	...	...	...	...	...	...	...	...	...	...	...	...	...
	20-25	24.6	...	...	...	...	...	...	...	...	...	...	...	...	...
	30-35	49.2	...	...	...	...	...	...	...	...	...	...	...	...	...
All	0-5	295.6	.195	.028	.067	.014	...	...	.076	...	.122	...	.069	.571	.188
	5-10	321.2	.308	.124	.039	.044	.022	...	.358	.010	.132	...	.107	1.143	.361
	10-15	343.7	.181	.019	.023	...	...	...	.092	...	.059	.009	.057	.440	.186
	15-20	380.9	.097	...	...	...	...	.089	.058	...	.103	...	.019	.366	...
	20-25	203.7	...	...	...	...	...	.190	.014	...	.430	...	...	.634	...
	25-30	35.2	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	30-35	253.4	...	...	...	...	...	...	...	...	.131	...	...	.131	...
	40-45	243.9	...	...	...	...	...	...	...	...	...	...	...	...	...
	0-45	2072.6	.781	.171	.129	.058	.022	.279	.598	.010	.977	.009	.252	3.285	.735

mon than the perch are the carp, white bass, cisco, largemouth black bass, rock bass, sucker. Among the small fishes alongshore the perch is also most abundant.

Green Lake is deep and its lower strata are always cool. Its shores are mostly sandy with little vegetation. The abundant fish in this lake is the cisco, and the perch is rare. The pickerel is quite common and shares the shallow water habitats with suckers, rock bass, bluegills, and smallmouth black bass. The smallmouth black bass is the most common of the small shore fishes. There are also Johnny darters, perch, largemouth black bass, blunt nosed minnows, top minnows, shiners, etc., alongshore.

Lake Geneva, like Mendota, stagnates somewhat in summer. Its deeper water remains fairly cool, in this respect being intermediate between Green Lake and Lake Mendota. Its shores are monotonous and stony. The dominant fish in this lake is the perch, but the rock bass approaches it in numbers. There are also many smallmouth black bass, ciscoes, and pike. Suckers and pickerel are quite common. The perch is most abundant among the small shore fishes, but smallmouth and largemouth black bass are quite common. There are apparently few or no darters.

Lake Michigan, in the region of Sturgeon Bay, has sandy and rocky shores. It is the largest and deepest of any of the lakes studied and its deeper parts are always cool. Its most abundant fish is the perch, with the pickerel second in numbers. In deep water the dominant fishes are ciscoes and lake trout. There are not many small fishes alongshore, but shiners, perch, smallmouth black bass, darters and other fishes occur.

Lake Pepin is in the direct course of the Mississippi River and, while its current is not rapid, the whole body of water is in continual motion. Lake Pepin is rather turbid and the summer temperatures are high at all levels (Table I). The gill nets show their smallest catch per hour in this lake, but more species are present than in any of the others. The sauger and sand sturgeon (hackleback) are the most common fishes. The perch, red horses, carp, and catfishes are also present in numbers. The log-perch is the most abundant small fish alongshore. Shiners, small pike, perch, and largemouth black bass were also quite common.

TABLE VI

GREEN LAKE. AVERAGE CATCH PER HOUR IN GILL NETS, AUGUST 13 TO SEPTEMBER 2, 1919*

Depth in meters	No. hours nets were set	<i>Ambloplites rupestris</i>	<i>Calostomus commersonii</i>	<i>Esox lucius</i>	<i>Lepomis tincior</i>	<i>Leucichthys birgei</i>	<i>Micropterus dolomieu</i>	<i>Perca flavescens</i>	Total Fishes
0-5	587.5	.050	.....	.120	.080	.....	.....	.....	.250
5-10	406.7	.050	.....	.064	.014	.....	.013	.013	.148
10-15	94.0	.....	.149	.....	.....	.....	.042	.....	.191
15-20	157.0	.....	.....	.....	.....	.....	.....	.....	0
20-25	110.0	.....	.....	.....	.....	.....	.....	.....	0
35-40	114.3	.....	.....	.....	.....	.....	.....	.....	0
40-45	136.5	.....	.....	.....	.....	.785	.....	.....	.785
45-50	118.0	.....	.....	.....	.....	.....	.....	.....	0
70-73	242.0	.....	.....	.....	.....	2.303	.....	.....	2.303
0-73	1966.0	.100	.149	.184	.094	3.088	.055	.013	3.677

* Condensed and rearranged from data already published (Pearse, 1921).

TABLE VII

LAKE MENDOTA. AVERAGE CATCH PER HOUR IN GILL NETS, JUNE 24 TO SEPTEMBER 5, 1919*

Depth in meters	No. hours nets were set	<i>Ambloplites rupestris</i>	<i>Calostomus commersonii</i>	<i>Cyprinus carpio</i>	<i>Esox lucius</i>	<i>Lepomis tincior</i>	<i>Leucichthys, species?</i>	<i>Micropterus salmoides</i>	<i>Perca flavescens</i>	<i>Pomoxis sparoides</i>	<i>Roccus chrysops</i>	<i>Sitostedion vitreum</i>	Total
0-5	586.0	.01	.01	.04	...	.01	...	...	.41	.01	.01	.01	.51
5-10	258.5	.01	.01	.08	.01	...	.01	.03	2.55	...	.04	...	2.74
10-15	402.5	...	...	.02	...	...	.03	...	1.74	...	...	...	1.79
15-20	142.5	...	...	...	...	...	...	...	...	...	...	...	...
20-24	357.5	...	...	...	...	...	.01	...	...	...	...	...	...
0-24	1747.0	.02	.02	.14	.01	.01	.05	.03	4.70	.01	.05	.01	5.05

* Condensed from data already published (Pearse, 1921).

In four of the lakes (Wingra, Mendota, Michigan, and Geneva) the yellow perch is the most abundant large fish. In Green Lake and Lake Pepin there are comparatively few perch; the cisco being the dominant species in the former, the sauger and sturgeon in the latter.

Many species of fishes were caught in only one of the six lakes studied. Though many of the fishes listed doubtless occur in lakes other than those mentioned, the fact that such species

were not caught during the present investigations indicates they are not abundant enough to be an important element in the fish fauna of a lake. For example, the writer has caught dog-fish in Lake Mendota, both in gill nets and in seines, but such catches are uncommon enough to make him feel that it is proper to accept the catches here considered as furnishing a fair representation of the fish life of the lake and its distribution during the summer season. As the various species of ciscoes have much the same habits everywhere, and are therefore ecologically similar,

TABLE VIII

COMPARISON OF TOTAL AVERAGE CATCH PER HOUR IN GILL NETS IN SIX WISCONSIN LAKES

Species	Lake Wingra †	Lake Geneva	Lake Mendota	Lake Pepin	Green Lake	Lake Michigan
<i>Ambloplites rupestris</i> .....	.....	.781	.020	.....	.100	.053
<i>Ameiurus melas</i> .....	.....	.....	.....	.005	.....	.036
<i>Amia calva</i>	.053	.....	.....	.....	.....	.....
<i>Carpoides</i> , 2 species .....	.....	.....	.....	.011	.....	.....
<i>Catostomus catostomus</i> .....	.....	.....	.....	.....	.....	.0007
<i>Catostomus commersonii</i> .....	.....	.171	.020	.....	.149	.053*
<i>Coregonus clupeiformis</i> .....	.....	.....	.....	.....	.....	.0004*
<i>Cristivomer namaycush</i> .....	.....	.....	.....	.....	.....	.0408*
<i>Cyprinus carpio</i>	.027	.....	.140	.027	.....	.012
<i>Esox lucius</i>	.036	.129	.010	.103	.184	.265
<i>Eupomotis gibbosus</i>	.329	.058	.....	.....	.....	.021
<i>Ictalurus punctatus</i> .....	.....	.....	.....	.025	.....	.....
<i>Lepisosteus osseus</i>	.062	.....	.....	.021	.....	.....
<i>Lepomis incisor</i>	.202	.022	.010	.....	.094	.....
<i>Leucichthys</i> , all species .....	.....	.279	.050	.....	3.088	.040*
<i>Lota maculosa</i> .....	.....	.....	.....	.....	.....	.004*
<i>Micropterus dolomieu</i>	.184	.598	.....	.....	.052	.....
<i>Micropterus salmoides</i>	.343	.010	.030	.....	.....	.....
<i>Moxostoma</i> , 2 species .....	.....	.....	.....	.207	.....	.....
<i>Notemigonus crysoleucas</i>	.212	.....	.....	.....	.....	.....
<i>Perca flavescens</i>	6.047	.977	4.700	.351	.010	2.538
<i>Pomoxis sparoides</i>	.208	.....	.010	.....	.....	.....
<i>Roccus chrysops</i> .....	.....	.....	.050	.005	.....	.....
<i>Salvelinus fontinalis</i> .....	.....	.009	.....	.....	.....	.....
<i>Scaphyrhynchus platyrhynchus</i> .....	.....	.....	.....	.885	.....	.....
<i>Stizostedion canadense</i> .....	.....	.....	.....	.911	.....	.....
<i>Stizostedion vitreum</i> .....	.....	.252	.010	.....	.....	.....
<i>Uranidea kumlienii</i> .....	.....	.....	.....	.....	.....	.00015*
Total	7.703	3.285	5.050	2.553	3.677	3.280*

* These averages are not directly comparable to others in this table as they came wholly or in part from Table IV.

† In Lake Wingra no 2-inch or 3-inch mesh nets were set (Pearse and Achtenberg, 1920). In the other lakes a "battery" including $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2, and 3-inch mesh nets was set.

they are not listed as pertaining to any particular lake. The fishes peculiar to certain lakes are as follows:

Lake Pepin—three species of the genus *Carpoides*, sauger, channel cat, mud cat, sand sturgeon, mooneye, gizzard shad, skipjack, spoonbill, pirate perch, duck-billed gar, a shiner (*Notropis jejunus*), two species of *Moxostoma*.

Lake Michigan—long-nosed sucker, whitefish, lake trout, cottid, lawyer.

Lake Wingra—dogfish, bream.

Lake Geneva—brook trout.

Lake Mendota—none.

Green Lake—none.

It is of interest to note that the lakes representing two primitive habitats on each drainage system have the largest number of species which are not found in other lakes. The reservoirs (Mississippi River and Great Lakes) which have since glacial times furnished the population of the inland lakes of Wisconsin have not sent all their species into the available localities. Some species migrated, others are specialized for life in large lakes and have never taken to streams or inland lakes. The true lake fishes (perch, cisco, long-nosed sucker, whitefish, lake trout) when conditions are favorable have entered inland lakes and often become abundant. The typical river fishes have been much less ready to enter the inland lakes of the Mississippi drainage system and many have never become an element in their fish fauna (red-horses, quillbacks, spoonbill, mooneye, gizzard shad, sauger, catfishes).

Lake Wingra more nearly approaches conditions characteristic of swamps than any of the lakes, and two fishes characteristic of swamps and creeks were caught in it, bream and dogfish. Lake Geneva is remarkable for its rocky shores, and hence has affinities with the rapids formations in brooks. Its peculiar fish is the brook trout, and the rock bass, smallmouth black bass and wall-eyed pike are more abundant in it than in any other lake.

In one of his papers Forbes (1910) said: "A lake is sessile, simple, stolid, coelenterate; a river is motile, complex, sensitive, and articulate: a lake has an aspect, a constitution; but a river has a character, a behavior." To the writer nothing is more inspiring than a lake, and no environment has more "character." A lake is also satisfactory for scientific study because it has a unity and orderly sequence that a barren, changeful river must

always lack. The results presented in this paper indicate that as conditions in lakes approach those in rivers the number of fishes per unit of area becomes fewer. Rivers are deserts among aquatic habitats. They are of most value to fishes as highways to lakes, swamps, and other aquatic Edens.

In the following summary the fishes that were caught in the writer's gill nets in two or more lakes are listed. Each species is followed by the names of the lakes where it was caught, the lakes being arranged in order according to the abundance of the species in them.

Yellow perch—Wingra, Mendota, Michigan, Geneva, Pepin, Green.

Pickereel—Michigan, Green, Geneva, Pepin, Wingra, Mendota.

Carp—Mendota, Wingra, Pepin, Michigan.

Rock bass—Geneva, Green, Michigan, Mendota.

Bluegill—Wingra, Green, Geneva, Mendota.

Ciscoes—Green, Geneva, Mendota, Michigan.

Largemouth black bass—Wingra, Mendota, Geneva.

Smallmouth black bass—Geneva, Wingra, Green.

Pumpkinseed—Wingra, Geneva, Michigan.

Common sucker—Geneva, Green, Mendota.

Black crappie—Wingra, Mendota.

White bass—Mendota, Pepin.

Black bullhead—Michigan, Pepin.

Long-nosed gar—Wingra, Pepin.

Wall-eyed pike—Geneva, Mendota.

The perch, bluegill, largemouth black bass, pumpkinseed, black crappie, and long-nosed gar were most abundant in the shallowest and smallest lake (Wingra). The pickerel and black bullhead were most abundant in the largest and deepest lake (Michigan). The carp and white bass were most abundant in the lake with the greatest degree of stagnation in summer, the most varied shores, and the richest bottom fauna (Mendota). The rock bass, smallmouth black bass, common sucker, and wall-eyed pike were most abundant in the clearest lake with the most rocky shores (Geneva). The ciscoes were most abundant in the deepest inland lake which has rather clear water (Green). No species of fish which is found in two or more lakes is most abundant in the lake (Pepin) which is closely associated with the great river.

The yellow perch and pickerel are the only species which were caught in gill nets in all of the six lakes studied. The perch

is distinctively a lake fish. Forbes and Richardson (1908) and Evermann and Clark (1920) reached the same conclusion after studying its habits in Illinois and Indiana. During the present investigation it was found to be the most abundant species in four of the six lakes studied. In Lake Mendota and Lake Geneva perch are the dominant deep water fishes, and it is of interest to note that the deeper water in both of these lakes loses its oxygen during the summer. It has been shown (Pearse and Achtenberg, 1920) that perch have unusual ability to endure stagnant water and this doubtless enables them to feed somewhat in deep water at all seasons. There is apparently a limit to the depth to which perch will migrate, for in Lake Michigan and Green Lake they are not found in the deepest water where ciscoes are the dominant fishes.

The pickerel is most abundant in the large, deep, clear lakes. The carp appears to be most common in lakes with muddy bottoms either in deep or shallow water and is rare in deep, clear lakes like Geneva and Green. The rock bass reaches its maximum where there are the most rocks alongshore and is absent from lakes like Wingra and Pepin. The bluegill is numerous in the small, shallow lake, but also quite common in the two deepest and clearest inland lakes. The pumpkinseed has a somewhat similar distribution. These two sunfishes are usually associated with the margins of swampy areas. The ciscoes are most abundant in deep lakes in which the lower water is cool in summer. They are present in the lakes in which the deeper water stagnates, but are less abundant.

The largemouth black bass feeds more on fishes than its smallmouth relative, which partakes more of insects. These differences probably account for the abundance of the former in the lakes where shore fishes are most numerous, and of the latter where insects abound. The common sucker reaches its maximum in the clear deep inland lakes. The black crappie was caught in the small shallow lake and in that with varied shores. The white bass is in the lake with varied shores and in that connected with a great river. The black bullhead was seldom caught in gill nets on account of morphological peculiarities and such catches probably have no significance. The long-nosed gar is associated with rivers and with an abundance of small fishes. The wall-eyed pike was caught in one of the deep, clear, inland

lakes and not in the other, though both lakes had been stocked with it. It was also taken in the lake with the most varied shores.

The statements in the last two paragraphs apply only to the results as judged by the writer's gill net catches. Though they doubtless fail to give a true picture in regard to various details, they are believed to give a general idea of the factors which are of importance in determining the distribution of the particular species considered.

The six lakes studied may also be compared on the basis of the catches with trot-line and seine. This is not possible for Lake Wingra where the shores are too muddy to use a small seine and where a trot-line was not set. With the trot-line, perch were more often caught than any other species in Lakes Green, Mendota, and Michigan. Bullheads and cat-fishes were regularly caught in Lake Pepin and perch were not taken on trot-lines. In Lake Geneva one rock bass was caught.

The minnow seine gives a means for judging the relative abundance of small fishes in shallow water. The following summary gives the leading fishes caught in each lake in order of their abundance:

Lake Mendota—perch, largemouth black bass, pumpkinseed and bluegill, top minnow, shiners, rock bass, etc.

Lake Geneva—perch, largemouth black bass, smallmouth black bass, bluegill, shiners, rock bass, etc.

Green Lake—smallmouth black bass, Johnny darter, largemouth black bass, blunt-nosed minnow, top minnow, shiner, pickerel.

Lake Michigan—blunt-nosed minnow, shiner, perch, smallmouth black bass, Iowa darter, etc.

Lake Pepin—log perch, shiners, pike, perch, largemouth black bass, bluegill and pumpkinseed, smallmouth black bass, etc.

The perch is the most abundant shallow water fish in two of the lakes and is among the species that are fairly abundant in two of the others, but is absent from the catches in Green Lake. A darter was the most abundant fish in Lake Pepin, but the most painstaking search failed to show a single darter in Lake Geneva. The two species of black bass were taken in considerable numbers in all the lakes. In general the seine hauls support the conclusions drawn from the catches with gill nets. They also give striking evidence of the "individuality" of the lakes.

FOOD OF THE FISHES

The methods used in determining the food of the fishes were the same as those described in previous papers (Pearse, 1918; Pearse and Achtenberg, 1920). All fishes were examined while fresh. The contents of the alimentary canal were stripped out on a glass plate; the entire canal was then slit open from end to end and the lining scraped to remove adhering food and parasites. The glass plate was then placed under a binocular and the food mass was slowly teased across the field with needles. The volume of each constituent was estimated. When necessary the food was also examined with a compound microscope.

In the following discussion all lengths of fishes are given in millimeters and do not include the tail fin. The numbers after foods indicate per cent of total volume; + means an amount less than .1 per cent.

FOOD OF FISHES IN LAKE PEPIN

Amia calva Linnaeus, dogfish

A female 578 mm. long, taken in a commercial seine on July 1, contained no food.

Anguilla chrysypa Rafinesque, eel

A single specimen was caught in a slew connected with the lower end of Lake Pepin, on a trot-line, July 7. It measured 810 mm. in length and had eaten nothing but crayfishes.

Aphredoderus sayanus (Gilliams), pirate-perch

Five specimens caught at the outlet of the lake July 9 in a minnow seine furnished the following data: Length: 26-32; average 30. Food: chironomid larvae 80; Cyclops 20. Four specimens contained no food.

Aplodinotus grunniens Rafinesque, sheepshead

Six adults from various sources were examined, June 28 to July 13. Length: 198-456; average 289. Food: fish 4; chironomid larvae 3.8; caddis-fly larvae 14; mayfly nymphs 9; Corethra pupae .2; Hyalella 1; unidentified amphipods 1.2; Leptodora 15.6; Daphnia 13.6; ostracods .2; snails 12; Sphaeridae 6; young clams 19. The largest specimen contained no food.

TABLE IX—Continued
FOOD OF FISHES IN LAKE PEPIN

Species	No. examined	Av. length	Birds	Fishes	Immature insects	Adult insects	Mites	Crayfishes	Amphipods	Cladocerans	Copepods	Ostracods	Snails	Clams	Oligochaetes	Nematodes	Rotifers	Sponges	Protozoans	Plants	Algae	Bottom	Unknown
<i>Micropterus salmoides</i>	12	67	..	17	19.9	..	10	..	1.5	29.4	22.2	..	..	..	..	..	..	..	..	..	..	..	..
<i>Morone chrysops</i>	1	242	..	..	10	..	45	..	..	45	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Maxostoma anisurum</i>	10	349	..	..	27	..	..	..	1.3	3.5	2.2	2.8	..	..	..	..	..	..	..	10	..	32.5	..
<i>Maxostoma breviceps</i>	10	289	..	..	67.7	..	+	..	.6	5	..	.3	..	..	..	..	..	..	..	12.4	1.1	11.4	..
<i>Notropis jejunus</i>	10	67	..	11.1	29	19.5	..	..	..	37.2	..	..	..	..	..	..	..	..	..	..	2.7	.6	..
<i>Notropis ludsonius</i>	10	27	..	..	5	..	..	..	95	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Notropis atherinoides</i>	6	33	..	..	..	..	..	..	..	100	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Notropis heterodon</i>	3	37	..	..	33	..	..	..	33	..	..	..	..	..	..	..	..	..	..	..	33	..	..
<i>Percina caprodes</i>	11	58	..	..	80.2	..	..	..	1.7	2	14.1	..	..	..	..	..	..	..	..	..	..	2	..
<i>Percia flavescens</i>	15	167	..	11.3	56.6	3	..	..	.7	18.8	..	..	..	..	..	..	..	..	..	3	..	2.7	..
<i>Polyodon spathula</i>	2	795	..	..	7.7	.7	..	..	..	49.5	7	1.8	..	..	..	..	..	..	..	1.3	10	18.7	..
<i>Pomolobus chrysocloris</i> ...	2	316	..	99	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Pomoxis annularis</i>	6	41	..	..	13.7	..	..	..	..	61.2	25.2	..	..	..	..	..	..	..	..	..	..	..	..
<i>Pomoxis sparoides</i>	6	122	..	5	7.4	.8	..	..	1.5	83	1.3	..	..	..	..	..	..	..	..	.8	.1	..	..
<i>Roccus chrysops</i>	12	161	..	34.2	19.3	.8	..	..	.8	44.8	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Scaphirhynchus platyrhynchus</i>	12	627	..	..	33.5	+	..	..	.7	61.8	.2	..	..	..	..	..	..	..	..	.2	.1	2.9	..
<i>Schilbeodes gyrinus</i>	5	44	..	..	57.5	..	2	..	39.5	..	..	.5	..	..	..	..	..	..	..	..	.5	..	..
<i>Stizostedion canadense</i> ...	10	206	..	75	2.5	..	..	..	1	1.5	1.5	2	..	..	..	..	..	..	..	..	..	6.5	10
<i>Stizostedion vitreum</i>	16	281	..	63.7	18.4	..	..	..	..	16.4	.9	..	..	..	..	..	..	..	..	..	..	..	.6
Average.....	..	..	13.15	4.21	2.1	1.66	.09	.7	1.65	24.7	4.92	3.62	2.91	1.85	.03	+	.12	.03	.10	1.85	3.81	7.45	.50

Ameiurus melas (Rafinesque), black bullhead

Nine adults, most of them taken from trot-lines set in the slews joining the lake near its outlet, were examined, June 25 to July 14. Length: 122-282; average 232. Food: fish 13.5; chironomid larvae .9; Helea larvae .4; mayfly nymphs 2.5; Sialis nymphs .6; dragon-fly nymphs .4; caddis fly larvae .6; Leptocerus larvae and cases 1.4; dytiscid larvae .4; Corixa .6; crayfish 29.5; Hyalella .5; Daphnia 9.9; Chydorus .1; Eurycercus .9; Leptodora 2.5; ostracods .1; Planorbis 2; plants 2.5; Arcella-like seeds .3; filamentous algae 19.9; diatoms 8.4; desmids .6; sand .4; mud .6. One specimen contained no food.

On July 7 a young specimen was caught in a dip net. It measured 37 mm. in length and had eaten: chironomid larvae 25; Ceriodaphnia 20; Cyclops 50; ostracods 5.

Ameiurus natalis (Le Seur), yellow bullhead

Ten adults were examined on July 6 and 8. Length: 234-417; average 285. Food: fish 57.8; crayfishes 26.1; Daphnia 2.6; ostracods 1.1; Planorbis .5; brow seeds 2.2; filamentous algae 2.2; sand .2; unknown 6.7. One specimen contained no food.

Ameiurus nebulosus (Le Seur), speckled bullhead

Three adults, caught in slews on trot-lines, were examined on July 7 and 10. Length: 258-306; average 286. Food: a nestling bird 15; minnows 11.7; midge pupae 1.7; insect remains .3; crayfishes 38.8; ostracods .2; Valisneria 33.3; fuzzy discoidal seeds .1.

Five young individuals caught at the margin of a slew with a dip net were examined on July 7. Length: 27-36; average 31. Food: chironomid larvae 18; water mites 1; Hyalella .4; Ceriodaphnia 27; Eurycercus 8.6; Chydorus 6.2; Alona .6; Bosmina 7.4; Cyclops 16.4; ostracods 13; sand 1.4.

Boleosoma nigrum (Rafinesque), Johnny darter

Ten specimens of this little darter were examined; June 29 to July 9; all being caught with a seine on sandy beaches. Length: 26-50; average 34. Food: chironomid larvae 78; Helea larvae 3; a maggot 2; Cyclops 3.5; ostracods 13; sand .5.

Carpoides carpio (Rafinesque), river carp

One individual, 264 mm. in length, was taken in a commercial seine June 22. Food: chironomid larvae 5; Cyclops 1; ostracods 30; algae 2; sand 5; bottom mud 57.

Carpoides thompsoni Agassiz, lake carp

Two adults were examined on July 1 and 6. Lengths: 372, 374. Food: chironomid larvae 10; Hyalella 1; Daphnia 6.5; Alona .5; Leptodora 5; Cyclops 2.5; ostracods 13; mud 51.5; sand 7.5.

A young specimen, 27 mm. long, was examined on July 7. Its food consisted of Chydorus 20; Alona 45; Cyclops 20; rotifers 10; Arcella 5.

Carpoides velifer (Rafinesque), quillback

Five specimens were examined, all caught along the shore of the lake, June 24 to July 10. Length: 128-376; average 236. Food: chironomid larvae 24; Corethra larvae 6; Corethra pupae 2; Alona .2; Ceriodaphnia 20; Cyclops 1; ostracods 13; rotifers 1.6; Arcella 2; desmids .6; diatoms .6; sand 19; bottom debris 10.

Catostomus commersonii (Lacépède), common sucker

Two adults caught in commercial seine were examined on June 30 and July 1. Lengths: 306, 309. Food: chironomid larvae 26.5; Corixa .5; Hyalella 1; Acroperus .1; Planorbis 1; Sphaeriidae 15; sponges 5; Ceratophyllum 29; sand 4; mud 6.

Five young specimens, caught in a minnow seine near the outlet of the lake on July 7 and 9, gave the following results: Length: 41-48; average 44. Food: fly .2; Cyclops 60; Eurycercus .4; Chydorus 4; Alona 7.4; ostracods 5.6; Diptera .2; Arcella .2; filamentous algae 20.4; desmids .4; sand .6; unknown .2.

Cyprinus carpio Linnaeus, carp

Nine carp over 100 mm. in length were examined, June 26 to July 8. Length: 122-344; average 229. Food: chironomid larvae 5.5; mayfly nymphs .6; fly larva +; beetle larva 2.2; bug nymphs +; Leptocerus larvae and cases 1.1; Leptocella larvae and cases +; Corethra pupae 3.3; midge pupae 2.2; fly pupae +; beetles .1; insects .1; Hyalella .9; Daphnia 1.9; Ceriodaphnia .1; Chydorus .7; Alona +; Eurycercus .9; Cyclops 11.1;

ostracods 4.8; Planorbis .1; snails 26.6; clams 7.8; Sphaeriidae .3; plants 8.8; Arcella-like seeds 1.7; filamentous algae 9.5; sand 3.7; bottom 1.1; unknown 4.4.

Two small carp were examined, June 25 and July 2. Length: 33, 73; average 53. Food: chironomid larvae 7.5; beetle larvae 5; chironomid pupae 50; Cyclops 32.5; ostracods 5.

Dorosoma cepedianum (Le Seur), gizzard-shad

Two specimens from a commercial seine were examined on July 13. They measured 283 mm. and 286 mm. in length and had eaten: chironomid larvae .5; Helea larvae 1.5; filamentous algae 22.5; sand 35.5; fine bottom débris 40.

Eupomotis gibbosus (Linnaeus), pumpkinseed

Eight small pumpkinseeds caught July 7 and 8 in a coulee opening Lake Pepin on the Minnesota shore gave the following results: Length: 87-102; average 92. Food: chironomid larvae 19; caddis fly larvae .3; beetle larvae .6; chironomid pupae .3; beetles 4.4; damsel fly 1; snails 73.8; plants .8.

Esox lucius Linnaeus, pickerel

Ten pickerel were examined, June 23 to 28. Length: 104-424; average 301. Food: fish 88.8; beetle larva 11.2. One individual contained no food.

Hiodon tergisus Le Seur, mooneye

Nine adults caught in a commercial seine were examined; June 25 to July 10. Length: 203-326; average: 246. Food: insect eggs 2.2; chironomid larvae .6; Corethra larvae 7.2; mayfly nymphs 3.3; Corethra pupae 25.6; chironomid pupae .3; beetles 1.4; Daphnia 36.7; Leptodora 21.9; plants .6.

Six small mooneyes, caught in a minnow seine alongshore, were examined, July 5 to 14. Length: 28-41; average 35. Food: Daphnia 54.2; Cyclops 45.8.

Ictalurus punctatus Rafinesque, channel-cat

Twelve specimens from various sources were examined, June 23 to July 14. Length: 246-412; average 307. Food: fish 9.4; chironomid larvae 1.1; fly larvae .1; damsel fly nymphs 1.2; mayfly nymphs 12; Sialis nymphs 26; Corixa nymphs +; beetle larvae .5; Leptocella larvae and cases 1.7; Leptocerus larvae and

cases .5; chironomid pupae 3.2; insects 4.2; beetle .1; crayfishes 4.5; Hyalella +; Cladocerans 1.8; Daphnia 12; Chydorus +; Leptodora 6.1; ostracods .1; oligochaetes .2; Diffugia +; plants 3.2; seeds .5; Wolffia .1; Closterium +; filamentous algae 34.5; diatoms .3; sand .2; bottom sediment .5. One specimen contained no food.

Ichthyomyzon concolor (Kirtland), silver lamprey

A specimen 206 mm. long which was taken from a spoon-bill on July 3 contained no food.

Ictiobus bulbalis (Rafinesque), smallmouth buffalo

A specimen 323 mm. long taken in a commercial seine on June 30 contained the following food: chironomid larvae 3; Hyalella 10; Acroperus 1; ostracods 61; Cyclops 1; *Planorbis bicarinatus* 2; Sphaeridae 15; plants 5; sand 2.

Ictiobus cyprinella (Cuvier and Valenciennes), redmouth buffalo

One individual 311 mm. long was caught in a commercial seine on July 12. Its food consisted of Daphnia 99; *Planorbis* .6; Diffugia .1; filamentous algae .3.

Ictiobus urus (Agassiz), mongrel buffalo

An individual 332 mm. long was examined on June 26, but contained no food.

Lepisosteus osseus (Linnaeus), long-nosed gar

Two specimens were examined, June 26, July 2. Lengths: 625, 743. Food: fish 92.5; Daphnia (perhaps from fishes eaten) 7.5.

Lepisosteus platostomus Rafinesque, short-nosed gar

Three gars caught in the slews connecting into Lake Pepin were examined on July 5, 6, and 11. Lengths: 424-522; average 475. Food: fish 3.3; crayfishes 96.7.

Leptopus olivaris (Rafinesque), mud-cat

A mud cat 420 mm. long was taken from a commercial seine on June 27. It contained no food.

Lepomis incisor Cuvier and Valenciennes, bluegill

Ten specimens were examined, June 29 to July 12. Length: 97-208; average 136. Food: fish .5; chironomid larvae 2.5;

Helea larvae +; caterpillars .5; mayfly nymphs 8.7; damsel fly nymphs 8; Leptocerus larvae and cases 2; chironomid pupae 2; insects 7.6; midges 1.2; grasshopper 3; bugs .5; Corixa 1; beetles 6.5; flies 2; ants .5; moths .8; mites 1.1; Hyalella 5.7; Daphnia 13.5; Eurycercus .1; Leptodora 5; snails 6.6; oligochaetes 1; plants 2.8; Ceratophyllum, 4.5; Valesneria .2; brown seeds .1; root .5; filamentous algae .1; chara 1.8; mud 9.7.

Micropterus dolomieu Lacépède, smallmouth black bass

Nine adults from various sources were examined, June 24 to July 10. Length: 106-364; average 214. Food: fish 75; water bug 12.5; crayfishes 12.5. One individual contained no food.

Three small individuals were examined, June 25 to July 7. Length: 33-40; average 37. Food: fish 6.7; chironomid larvae 1; Orthocladus larvae 53.3; Corixa nymphs 16.7; beetle larvae 1.7; Daphnia 10; Ceriodaphnia 8.3; Cyclops 1.7; ostracods .7.

Micropterus salmoides Lacépède, largemouth black bass

Two adults from a commercial seine were examined, July 6. Lengths: 178, 206. One had eaten crayfishes; the other contained no food.

Ten small bass examined June 28 to July 5 gave the following results: Length: 33-53; average 42. Food: *Notropis hudsonius* 18.9; chironomid larvae 3.8; damsel fly nymphs 7.8; mayfly nymphs 10.6; Hyalella 1.7; Daphnia 20.6; Ceriodaphnia 1.2; Eurycercus .4; Cyclops 24.7. One individual contained no food.

Morone interrupta Gill, yellow bass

A specimen caught in a commercial seine, July 10, was 242 mm. in length and had eaten: Corethra larvae 10; crayfishes 45; Leptodora 45.

Moxostoma anisurum (Rafinesque), white-nosed sucker

Ten specimens from Lake Pepin and the slew connecting with it were examined, June 24 to July 3. Length: 164-446; average 349. Food: insect nymph .6; chironomid larvae 22; Corethra larvae .2; mayfly nymphs 2.8; beetle larvae .1; chironomid pupae 1.2; Corethra pupae .1; Hyalella 1.3; Daphnia .8; Leptodora 2.7; Cyclops 2.2; ostracods 2.8; snails .3; Sphaeriidae 19.9; plants 10; fine bottom sediment 6.7; sand 7.8; mud 18. One individual contained no food.

Moxostoma breviceps (Cope), short-headed red-horse

Ten specimens caught in the slews connecting with Lake Pepin were examined, June 28, July 2. Length: 171-354; average 289. Food: insect eggs .3; chironomid larvae 60.6; mayfly nymphs 1.7; caddis fly larvae 2.8; beetle larvae 1.1; midge pupae 1.2; mites +; Hyalella .6; cladocerans .1; Daphnia 4.7; Eurycercus .2; Chydorus +; ostracods .3; snails 1.7; plants 11.8; Ceratophyllum .6; algae 1.1; fine bottom sediment 8.7; sand 2.7. One individual contained no food.

Notropis jejunus (Forbes), shiner

Ten specimens, caught in a minnow seine alongshore, were examined on June 22, 25. Length: 62-74; average 67. Food: fish 11.1; Corethra larvae .6; midge pupae 2.2; chironomid pupae 9.5; Corethra pupae 16.7; insects 18.9; midges .6; Daphnia 37.2; algae 1.1; filamentous algae 1.1; diatoms .3; Closterium .2; sand .6. One individual contained no food.

Notropis hudsonius (De Witt Clinton), spot-tailed minnow

Ten individuals, caught in a minnow seine alongshore were examined, June 29, July 5. Length: 25-28; average 27. Food: chironomid larvae 2; caddis fly larvae and cases 3; Daphnia 51; Ceriodaphnia 42.5; Scapholeberis 1.

Notropis atherinoides Rafinesque, shiner

Six individuals caught with a minnow seine alongshore were examined, July 12, 14. Length: 27-64; average 33. Food: Daphnia 100. One individual contained no food.

Notropis heterodon (Cope), shiner

Three individuals were examined, July 5, 7, 9. They were caught in a minnow seine alongshore and each had eaten a single food, respectively: midge pupae, cladocerans, and algae. Their lengths were 35, 35, 40.

Percina caprodes (Rafinesque), log perch

Eleven log perch, caught alongshore, were examined, June 25 to July 7. Length: 30-157; average 58. Food: chironomid larvae 56.1; mayfly nymphs 3.3; chironomid pupae 20.8; Hyalella 1.7; cladocerans .3; Daphnia 1.7; Cyclops 14.1; sand 2. Two individuals contained no food.

Perca flavescens (Mitchill), yellow perch

Fifteen perch from various sources were examined, June 24-28. Length: 122-237; average 167. Food: fish 11.3; chironomid larvae 20.2; Corethra larvae 8.1; mayfly nymphs 10; chironomid pupae 6; Corethra pupae 12.3; ants (?) 3; Hyalella .7; Daphnia 7; Leptodora 5.1; Eurycercus 6.7; snails .3; clams 5.5; bud scale .3; sand 1.7; bottom sediment 1.

Polyodon spathula (Walbaum), spoonbill

Two spoonbills from a commercial seine were examined July 2. Length: 620, 870; average 795. Food: chironomid larvae 5; mayfly nymphs 2.7; beetle .7; Daphnia 7.3; *Bosmina longirostris cornuta* 31.5; Chydorus .7; Leptodora 10; Cyclops 7; ostracods 1.8; filamentous algae 10; sticks 1.3; sand 7; "organic" mud 11.7.

Pomolobus chrysochloris Rafinesque, skipjack

Two adults from a commercial seine were examined on July 1. Lengths: 306, 326. Food: fish 99; insect larvae 1.

Pomoxis annularis Rafinesque, white crappie

No adults were examined. Six young from a minnow seine were examined, July 7, 9, 12. Length: 33-47; average .41. Food: chironomid larvae 8.7; midge pupae 5; Daphnia 38.7; Leptodora 22.5; Cyclops 17.5; Diaptomus 7.7.

Pomoxis sparoides (Lacépède), black crappie

Six individuals were examined, June 29 to July 12. Length: 44-172; average 122. Food: fish 5; chironomid larvae 1; Corethra larvae .2; mayfly nymphs 3.6; damselfly nymphs .8; caterpillar .8; midge pupae .3; Corethra pupae 1.7; Corixa .8; Hyalella 1.5; Daphnia 76.7; Eurycercus +; Leptodora 6.3; Diaptomus 1.3; plants .8; filamentous algae .1.

Roccus chrysops (Rafinesque), white bass

Seven adults, mostly from a commercial seine, were examined, June 24 to July 10. Length: 144-323; average 242. Food: fish 8.6; insect larvae .7; chironomid larvae 5; Sialis nymphs 1; Corethra pupae 23.6; Corixa 1.4; Daphnia 5.7; Leptodora 53.9.

Five small specimens were examined, July 9. Length: 46-51; average 49. Food: fish 70; chironomid pupae 4; Hyalella 2; Daphnia 11; Leptodora 13.

Scaphirhynchus platyrhynchus (Rafinesque), hackleback

Twelve specimens were examined, June 23, 30. Length: 565-680; average 627. Food: chironomid larvae 17.5; Corethra larvae 2.7; caddis fly larvae +; Sialis nymphs 8.9; mayfly nymphs .3; chironomid pupae .5; Corethra pupae 2.9; Corixa +; Hyalella .7; Daphnia 23.7; Leptodora 38.1; Cyclops .2; snail .7; Sphaeridae .2; young clams 1.2; gordiacean (from insect larva?) +; Ceratophyllum +; Chara +; stick .2; filamentous algae .1; sand 1.1; bottom débris 1.7.

Schilbeodes gyrimus (Mitchill), tadpole cat

Five specimens were caught with a dip net, June 23—July 1. Length: 16-67; average 44. Food: chironomid larvae 30; mayfly nymphs 27.5; mites 2; Hyalella 39.5; ostracods .5; filamentous algae .5. One individual contained no food.

Stizostedion canadense griseum (De Kay), sauger

Ten saugers were examined, June 22 to 24. Length: 113-275; average 206. Food: fish 65; small pike 10; chironomid larvae 2.5; Hyalella 1; Daphnia .5; Leptodora 1; Cyclops 1.5; ostracods 2; mud 2.5; bottom débris (partly chironomid tubes) 4; unknown 10.

Stizostedion vitreum (Mitchill), wall-eyed pike

Eleven adults, taken in a commercial seine, were examined, June 25 to July 10. Length: 330-415; average 386. Food: fish 79; Sialis nymphs 21.

Five small pike caught alongshore in a minnow seine July 25 furnished the following data: Length 48-53; average 52. Food: fish 30; chironomid pupae 13; Daphnia 52; Leptodora .4; Cyclops 3; unknown 2.

FOOD OF THE FISHES IN LAKE MICHIGAN

Ambloplites rupestris (Rafinesque), rock bass

Six specimens were examined, July 23 to August 6. Length: 132-200; average 156. Food: minnows 17.5; mayfly nymphs 21.7; crayfishes 60.8.

TABLE X
FOOD OF THE FISHES IN LAKE MICHIGAN

Species	No. examined	Av. length	Fishes	Immature insects	Adult insects	Mites	Crayfishes	Schizopods	Isopods	Amphipods	Cladocerans	Copepods	Ostracods	Snails	Clams	Oligochaetes	Nematodes	Protozoans	Plants	Algae	Bottom	Calcium carbonate crystals	Unknown
<i>Ambloplites rupestris</i>	6	156	17.5	21.7	...	...	60.8	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...
<i>Ameiurus melas</i>	4	21	...	1.2	23.8	...	71.3	...	...	1.8	+	...	...	...	...	...	...	...	...	...	...	...	...
<i>Ameiurus nebulosus</i>	6	232	28.3	3.2	...	...	29.7	...	2	30.3	1.9	...	...	1	...	...	...	...	...	...	3	...	1.7
<i>Bosmina nigra</i>	4	31	...	92	...	...	...	...	...	...	5.6	2.5	...	...	...	...	...	...	...	...	...	...	...
<i>Calosoma calosomus</i>	4	414	...	...	...	...	...	...	...	80.6	...	...	...	...	5.3	...	...	...	+	...	6.3	7.5	...
<i>Calosoma commersonii</i>	19	166	...	12.4	...	+	...	...	2.5	7.4	24.8	1.9	24.9	1.9	3.3	...	+	...	+	...	20.8	...	...
<i>Coregonus cupeformis</i>	3	429	...	3	...	...	...	...	...	50	...	...	...	...	25	...	...	...	...	...	24.3	...	...
<i>Cristomer namaycush</i>	10	378	90	...	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Cyprinus carpio</i>	1	606	...	16	...	...	20	...	...	...	22	...	2	...	15	...	...	...	...	...	20	...	...
<i>Esox lucius</i>	15	494	92.9	7.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Etheostoma caeruleum</i>	5	42	...	66	...	...	...	...	...	24	2	...	...	...	...	8	...	...	...	...	5	...	...
<i>Eupomotis gibbosus</i>	3	149	6.7	67.6	6.3	...	...	...	...	...	2.4	...	...	...	...	...	...	...	...	...	5	...	...
<i>Fundulus diaphanus menona</i>	1	58	...	80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Leucichthys harengus</i>	5	208	1.3	8.15	...	...	...	...	...	70.2	...	...	...	...	3	...	...	...	...	1.8	...	...	...
<i>Leucichthys hoyi</i>	9	174	...	...	...	...	60	...	...	39	...	1	...	...	2.9	...	...	...	...	1	2.9	...	...
<i>Leucichthys johanna</i>	8	237	...	...	...	...	80	...	...	14.3	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Leucichthys nigripinnis</i>	2	317	...	...	...	...	90	...	...	...	...	10	...	...	...	...	...	...	...	...	...	...	...
<i>Lota maculosa</i>	11	472	83.8	...	...	...	...	8.9	...	3.3	...	...	...	...	6	...	...	...	...	...	2.8	...	...
<i>Micropterus dolomieu</i>	2	271	98.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1.5	...	...	...
<i>Micropterus salmoides</i>	1	48	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Notemigonus crysoleucas</i>	5	62	...	26	...	...	...	...	...	2	70.8	...	...	...	...	...	...	...	...	...	...	...	...
<i>Notropis atherinoides</i>	7	59	49.7	50	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...
<i>Notropis hudsonius</i>	11	39	...	16.4	...	...	...	...	...	18	28.3	4.1	28.2	...	...	...	...	...	...	...	5	...	...
<i>Percia flavescens</i>	27	147	19	36.8	...	...	13.3	1.5	3.7	8.1	11.2	5	6	...	...	...	...	...	+	...	2.2	...	2.4
<i>Perca caprodes</i>	5	88	...	46.8	...	...	...	...	...	...	34.2	...	...	...	...	...	...	...	...	...	...	...	...
<i>Pimephales notatus</i>	5	55	...	39	...	...	...	...	...	...	14	...	...	...	...	...	...	...	...	...	27	...	20
<i>Uronida kumlieni</i>	5	81	...	...	...	...	...	57.5	...	42.5	...	...	...	...	...	...	...	...	...	...	...	...	...
Average.....	...	...	21.8	21.9	2.04	+	7.23	11.0	.94	14.2	7.97	.71	2.06	1.08	.07	.70	.1	.1	.1	.1	.1	.1	.1

Ameiurus melas (Rafinesque), black bullhead

Four specimens were examined, July 20-24. Length: 196-218; average 208. Food: chironomid larvae 1.1; mayfly nymphs 1; chironomid pupae .1; dragon flies 23.8; *Cambarus virilis* 71.3; *Hyaella* 1.8; *Eurycercus* +; plants .5; *Scirpus* 1.5.

Ameiurus natalis (Le Seur), yellow bullhead

One specimen 216 mm. long was examined July 21 and contained no food.

Ameiurus nebulosus (Le Seur), speckled bullhead

Six speckled bullheads were examined, July 21, 23. Length: 196-276; average 232. Food: fish 28.3; chironomid larvae 3; chironomid pupae .2; crayfishes 29.7; *Hyaella* 30.3; *Asellus* .2; *Daphnia* 1.7; *Eurycercus* .2; *Physa* 1; plants .8; fine debris 3; unknown 1.7.

Boleosoma nigrum (Rafinesque), Johnny darter

Four individuals were caught in Sturgeon Bay with a minnow seine, July 19, 21. Length: 24-46; average 31. Food: chironomid larvae 92; cladocerans 1.3; *Eurycercus* 3.8; *Acroperus* .5; *Cyclops* 2.5.

Catostomus catostomus (Forster), long-nosed sucker

Four individuals were examined, July 22, 27. Length: 402-430; average 414. Food: midge pupae .3; arthropods 42.3; *Pontoporeia hoyi* 38.3; Sphaeriidae 5.3; seed +; sand 6.3; calcium carbonate crystals 7.5.

Catostomus commersonii (Lacépède), common sucker

Eleven adults were examined July 23 to August 6. Length: 175-335; average 262. Food: chironomid larvae 12.7; mayfly nymphs 7.1; Agraylea larvae and cases .5; *Leptocerus* larvae and cases .3; chironomid pupae .2; mite .1; amphipods 7.2; *Hyaella* 3.5; *Asellus* 1.5; entomostracans 1; *Daphnia* 1; *Ceriodaphnia* 5.6; *Eurycercus* 9; *Pleuroxus* +; *Alona* 6; ostracods 1.5; Sphaeriidae 6.1; *Physa* 2.1; *Ammicola* .7; *Planorbis* .8; plants .1; sand 26.3; fine bottom sediment 8.9. One specimen contained no food.

Eight small individuals were examined, July 19, 29. Length: 29-37; average 33. Food: chironomid larvae 1.9; *Hyaella* 3.4;

Asellus 3.8; Daphnia 1.2; Chydorus 1.4; Alona 25.6; Cyclops 2.1; ostracods 54.1; Diffugia .4; sand 3.3; fine bottom débris .6.

Coregonus cupeiformis (Mitchill), whitefish

Three specimens, examined on July 22, furnished the following data: Length: 412-448; average 429. Food: chironomid larvae .3; *Pontoporeia hoyi* 50; Sphaeridae 25; gordiacean (from insect larvae?) +; stick .3; sand 24.3.

Cristvomer namaycush (Walbaum), lake trout

Ten specimens were examined on July 22 and 26. Length: 236-580; average 378. Food: fish 46; Uranidea 21; *Leucichthys hoyi* 23; grasshoppers 10. One individual, taken in a gill net at a depth of seventy fathoms and twelve miles from shore, had three grasshoppers in its stomach and the remains of others in its intestine.

Cyprinus carpio Linnaeus, carp

On July 22 one individual was caught in a gill net set in a swampy region along the shore of Sturgeon Bay. Length: 606. Food: chironomid larvae 15; caddis fly larvae 1; crayfishes 20; Daphnia 2; Eurycercus 20; ostracods 2; Sphaeridae 15; plants 5; fine bottom sediment 20.

Esox lucius Linnaeus, pickerel

Fifteen pickerel were examined, July 20 to August 3. Length: 157-764; average 494. Food: fish 54.7; perch 11.4; cisco 27.1; mayfly nymphs 7.1. One individual contained no food.

Etheostoma iowae Jordan and Meek, Iowa darter

Five of these darters were examined on July 19. Length: 41-45; average 42. Food: chironomid larvae 56; chironomid pupae 10; Hyalella 24; Daphnia 2; oligochaetes 8.

Eupomotis gibbosus (Linnaeus), pumpkinseed

Three pumpkinseeds were caught along the marshy areas in Sturgeon Bay, July 19, 23. Length: 140-156; average 149. Food: Pimephales 6.7; chironomid larvae 40.7; Agraylea larvae and cases 1; mayfly nymphs 3.3; Sialis nymphs 13.3; chironomid pupae 9.3; beetle 6.3; Daphnia .7; Eurycercus 1.7; snails 6.3; plants 1.7; seeds 3.3; chironomid tubes 5.

Fundulus diaphanus menona Jordan and Copeland, top-minnow

One specimen was examined July 19. Length 58. Food: chironomid larvae 55; chironomid pupae 25; snails 10; Physa 10.

Leucichthys hoyi (Gill), bloater

Ten bloaters were examined, July 22. Length: 116-247; average 184. Food: Mysis 60; Pontoporeia 39; Diaptomus .1; Sphaeridae .8; seed .1. Five individuals contained no food.

Leucichthys harengus (Richardson), herring

Five specimens were taken at Little Harbor July 31 and August 3. Length: 172-247; average 208. Food: fish 1; Pontoporeia 56.2; mayfly nymphs 7; mayflies 12; Sphaeridae 2.4; seeds .2; old wood 1.2.

Leucichthys johannae (Wagner), chub

Eight chubs were examined, July 26, 27. Length: 207-312; average 237. Food: Mysis 80; Pontoporeia 14.3; Sphaeridae 2.9; bottom ooze 2.9. One individual contained no food.

Leucichthys nigripinnis (Gill), blackfin

Two individuals were studied, June 24. Length 308, 325; average 317. Food: Mysis 90; Diaptomus 10. One individual contained no food.

Leucichthys prognathus (H. M. Smith), longjaw

One longjaw, 364 mm. in length, examined July 17, contained no food.

Lota maculosa (Le Seur), lawyer

Ten lotas were examined, July 22, 27. Length: 350-560; average 472. Food: fish 43.8; bloaters 40; Mysis 8.9; amphipods 3.3; Sphaeridae .6; bottom mud 2.8. One individual contained no food.

Micropterus dolomieu Lacépède, smallmouth black bass

Two specimens, measuring 387 and 155 mm. were examined, July 19, 24. Food: fish 50; perch 30; Pimephales 18.5; chara 1.5.

Micropterus salmoides (Lacépède), largemouth black bass

A little bass 48 mm. long caught on August 3 had eaten nothing but fish.

Notemigonus crysoleucas (Mitchill), bream

Five breams were examined, July 19, 21. Length: 49-81; average 62. Food: chironomid pupae 26; Hyalella 2; Daphnia 70.8; Cyclops .2; Chara 1.

Notropis atherinoides Rafinesque, shiner

Seven specimens were examined, July 21. Length: 48-75; average 59. Food: chironomid pupae 49.7; midges 50; sand .4. One individual contained no food.

Notropis hudsonius (De Witt Clinton), shiner

Eleven shiners were examined, July 19, 21, 29. Length: 29-51; average 39. Food chironomid larvae 14.4; chironomid pupae 2; Hyalella 18; Daphnia 21; Alona 7.3; Cyclops 4.1; ostracods 28.2; mud .5; sand 4.5. One individual contained no food.

Necturus maculosus Rafinesque, mud puppy²

A mud puppy was caught on a trot-line in Sturgeon Bay, July 20. Its food consisted of: fish 3; minnows 97.

Perca flavescens (Mitchill), yellow perch

Twenty-two adult perch were examined, July 19 to August 5. Length: 117-240; average 163. Food: fish 12.8; ciscoes 5.2; minnows 5; chironomid larvae 1.1; mayfly nymphs 38.9; chironomid pupae .6; amphipods 1.2; isopods 2.5; crayfishes 12.8; Mysis 19; Alona +; Daphnia 1.1; Eurycerus .2; Chydorus +; ostracods .1; mud 2.8; unknown 3.1. Four individuals contained no food.

Five small perch were examined, July 19. Length 71-87; average 77. Food: *Micropterus dolomieu* 3; chironomid larvae 13.4; damsel fly larvae 6; chironomid pupae 3.8; crayfishes 16; Hyalella 32.8; Asellus 8; Daphnia 9.6; Eurycerus .4; Cyclops 2.2; ostracods .4; plant .2.

² Not a fish.

TABLE XI
FOOD OF THE FISHES IN LAKE GENEVA

Species	No. examined	Av. length	Fish	Immature insects	Adult insects	Mites	Spiders	Crayfishes	Amphipods	Cladocerans	Copepods	Ostracods	Snails	Clams	Oligochaetes	Nematodes	Plants	Algae	Bottom	Unknown
<i>Ambloplites rupestris</i>	14	107	15	37.7	16.8	3.9	15.6	1.7	9.4	5.7	20.3	1.1	20.3	1.1	3.7	+	.3	1.29	.7	...
<i>Calostomus commersonii</i>	10	200	...	17.9	.2	...	...	8.5	12.2	5.7	22.6	2.3	22.6	2.3	.6	...	.1	.4	1.3	...
<i>Eupomolis gibbosus</i>	8	90	100	67.5	...	.1	...	5	...	...	...	...	...	...	...	...	...	...	...	...
<i>Esox lucius</i>	9	547	100	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...
<i>Leucichthys arledisisco</i>	12	225	...	...	...	...	...	...	...	88	11	...	...	...	...	...	...	...	...	...
<i>Lepomis incisor</i>	12	76	...	63.7	3.8	5	4	11.5	7.1	...	...	.4	1	...	...	8.3	+	.5	.1	...
<i>Micropterus dolomieu</i>	21	218	33	9.9	33.1	...	...	...	+	...	...	...	...	...	...	...	...	...	...	3
<i>Micropterus salmoides</i>	15	116	23.7	22.8	7.7	...	20.6	...	35.3	...	2.2	+	...	...	...	1.7	...	...	...	...
<i>Notropis hudsonius</i>	12	41	...	24.2	18.6	.4	6.7	...	42.1	...	...	...	...	...	11.7	...	...	.4	1.7	...
<i>Perca flavescens</i>	19	138	5.3	20.5	...	...	5.6	19.9	33.5	...	.3	.1	2.7	...	...	...	.6	...	11.1	...
<i>Salvelinus fontinalis</i>	1	315	...	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
<i>Stizostedion vitreum</i>	10	274	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Average.....	...	...	23.1	30.4	6.60	7.8	+4.04	3.9	18.9	1.17	.52	3.88	.37	1.33	+	.92	.12	3.62	.25	...

Percina caprodes (Rafinesque), log-perch

Five of these darters were collected in Little Harbor, August 3, 5. Length: 77-100; average 88. Food: chironomid larvae 17.4; mayfly nymphs 15.6; caddis fly larvae and cases 8; Psephenus larvae 4; chironomid pupae 1.8; Asellus 19; Daphnia 34.2.

Pimephales notatus (Rafinesque), blunt-nosed minnow

Five specimens were examined, July 19. Length: 48-62; average 55. Food: chironomid larvae 18; chironomid pupae 21; Daphnia 14; fine debris 25; sand 2; unknown 20.

Uranidea kumlienii Hoy, cottid

Five specimens were examined, July 22, 26. Length 61-103; average 81. Food: Mysis 57.5; Pontoporeia 42.5. One individual contained no food.

FOOD OF FISHES IN LAKE GENEVA

Ambloplites rupestris (Rafinesque), rock bass

Six adults were examined, August 9-14. Length: 140-222; average 197. Food: fish 35; insect eggs 1.7; mayfly nymphs 20.8; dragon fly nymphs 7.5; beetle 10; crayfishes 20.8; Daphnia 2.5; bottom mud 1.7.

Eight small individuals, studied August 9-20, furnished the following data: Length: 22-96; average 39. Food: chironomid larvae 24.5; mayfly nymphs 18.8; chironomid pupae .2; insects 4.4; midges 17.5; mites 2.5; crayfishes 11.8; Hyalella 3.1; Daphnia 8.8; Eurycercus 4.5.

Catostomus commersonii (Lacépède), common sucker

Ten individuals were examined, August 13-19. Length: 145-350; average 200. Food: insect larva .1; chironomid larvae 15.7; Helea larvae +; mayfly nymphs .4; Sialis nymphs .5; Leptocella larvae and cases .8; Molanna larvae and cases .1; beetle larvae .3; bugs .2; Hyalella 8.5; cladocerans .5; Pleuroxus +; Chydorus +; Alona +; Daphnia 11.6; Cyclops .5; ostracods 5.7; snails 20.3; Sphaeridae 1.1; oligochaetes 3.7; plants .3; algae .1; bottom sediment 13.6; sand 15.4.

Eupomotis gibbosus (Linnaeus), pumpkinseed

No large pumpkinseeds were caught, but eight small individuals were examined, August 10-18. Length: 81-115; aver-

age 90. Food: chironomid larvae 49.1; mayfly nymphs 13; caddis fly larvae 1.3; Leptocerus larvae and cases .3; beetle larvae .3; Psephenus larvae 1.9; chironomid pupae 1.6; mites .1; Hyalella 5; snails 22.6; Ancylus .3; Sphaeriidae 2.3; oligochaetes .6; Chara .3; seeds .1; filamentous algae .1; sedimentary débris 1.3.

Esox lucius Linnaeus, pickerel

Nine pickerel were examined, August 13-26. Length: 415-645; average 615. Food: fish 833; ciscoes 16.7. Three individuals contained no food.

Leucichthys artedisisco Jordan, cisco

Twelve ciscoes were examined, August 24, 25. Length: 200-248; average 225. Food: Daphnia 88; Cyclops 11; Sphaeriidae 1. Two individuals contained no food.

Lepomis incisor Cuvier and Valenciennes, bluegill

One adult, 153 mm. in length was examined, August 14. It had eaten: chironomid larvae 2; plants 98.

Eleven small bluegills were examined, August 9-17. Length: 64-84; average 69. Food: insect eggs .1; chironomid larvae 53; chironomid larvae in tubes 3.6; mayfly nymphs .1; Agraylea larvae and cases 5; Psephenus larvae 6; chironomid pupae 1.7; insects 2.3; Plea+; midges .9; beetles .9; mites 5.5; spiders .5; Hyalella 12.5; Daphnia 7.5; Pleuroxus .1; Bosmina .1; ostracods .4; snails .1; plants .1; Arcella-like seeds .1; filamentous algae .5; sand 2; sedimentary débris .5.

Micropterus dolomieu Lacépède, smallmouth black bass

Twenty smallmouth bass over 100 mm. in length were examined, August 10-25. Length 105-350; average 220. Food: fish 23.2; perch 11.9; mayfly nymphs 7.4; Sialis nymphs 1.9; insects 18.1; bugs 1.4; mayflies 6.9; beetles 3.4; crane fly .4; crayfishes 21.9; Leptodora .4; Ceratophyllum .1; unknown 3.1. Four individuals contained no food.

One individual, 95 mm. long, was examined August 10. It had eaten: Mayfly nymphs 20; midges 80.

Micropterus salmoides (Lacépède), largemouth black bass

Five adults were examined, August 12-23. Length: 185-322; average 256. Food: fish 53; chironomid pupae 2; mayflies 20; crayfishes 20; plants 5.

Ten small individuals were examined, August 12, 16. Length 42-52; average 46. Food: fish 9; chironomid larvae 7.2; mayfly nymphs 9; bug nymphs 1.5; chironomid pupae 14.5; insects 1.5; Daphnia 51.4; Ceriodaphnia 1.5; Diaptomus 3.3; ostracods .1.

Notropis hudsonius (De Witt Clinton), shiner

Twelve shiners were studied, August 12-19. Length: 33-53; average 41. Food: chironomid larvae 22.1; chironomid pupae 2.1; insects 17.3; midges 1.3; entomostracans 3.8; Daphnia 38.3; mite .4; oligochaetes 11.7; filamentous algae .4; mud (chironomid larval tubes?) 1.7.

Perca flavescens (Mitchill), yellow perch

Nineteen perch were examined, August 10-21. Length: 98-195; average 138. Food: fish 5.3; chironomid larvae 15.8; mayfly nymphs 2.8; Sialis nymphs 1.1; caddis fly larvae .7; beetle larvae .1; crayfishes 5.6; Hyalella 19.9; Daphnia 25.3; Eurycercus .2; Leptodora 8; Diaptomus .3; ostracods .1; snails 2.7; plants .6; Arcella-like seeds +; bottom 11.1. One individual contained no food.

Salvelinus fontinalis (Mitchill), brook trout

A specimen, 315 mm. long, caught August 24, had eaten nothing but chironomid pupae.

Stizostedion vitreum (Mitchill), wall-eyed pike

Ten pike were examined; August 13-24. Length: 208-300. Average 274. Food: fish 75; perch 25. Two individuals contained no food.

DISCUSSION OF FOODS OF FISHES IN ALL LAKES

The observations on the foods eaten by the fishes in Lake Wingra are not extensive enough to be compared with those from other lakes and the following discussion therefore relates to five Wisconsin lakes. The foods are summarized in Tables IX to XII.

The following list gives the classes of foods and the lakes in which the foods were found to be eaten by fishes. The lakes are arranged according to the volume of the total that each item

constituted in their food. The lake showing the largest amount comes first.

Birds—Pepin.

Fishes—Geneva, Michigan, Mendota, Pepin, Green.

Immature Insects—Geneva, Green, Michigan, Pepin, Mendota.

Adult Insects—Mendota, Geneva, Green, Michigan, Pepin.

Mites—Geneva, Green, Pepin, Mendota, Michigan.

Crayfishes—Pepin, Michigan, Green, Mendota, Geneva.

Mysis—Michigan, Green.

Amphipods—Green, Michigan, Geneva, Mendota, Pepin.

Isopods—Michigan.

Cladocerans—Pepin, Geneva, Mendota, Michigan, Green.

Copepods—Pepin, Mendota, Geneva, Michigan, Green.

Ostracods—Mendota, Pepin, Green, Michigan, Geneva.

Clams—Green, Michigan, Pepin, Mendota.

Snails—Mendota, Green, Geneva, Pepin, Michigan.

Leeches—Mendota, Green.

Oligochaetes—Green, Michigan, Geneva, Mendota, Pepin.

Rotifers—Pepin.

Sponges—Pepin.

Protozoans—Pepin, Mendota, Michigan.

Plants—Mendota, Green, Pepin, Geneva, Michigan.

Algae—Mendota, Pepin, Green, Geneva, Michigan.

Bottom—Pepin, Mendota, Green, Michigan, Geneva.

Calcium carbonate crystals—Michigan.

Unknown—Michigan, Pepin, Green, Geneva.

Fishes, immature insects, adult insects, mites, crayfishes, amphipods, cladocerans, copepods, ostracods, clams, snails, oligochaetes, flowering plants, algae, and bottom sediment were eaten by fishes in all the lakes. The bird eaten by a bullhead in Lake Pepin probably came from a nest that had been covered by high water, and such an event would seldom, if ever, happen in any of the other lakes. Isopods were found as a constituent of food only in Lake Michigan; rotifers and sponges, only in Lake Pepin. Leeches were found in Mendota and Green Lake; protozoans in Pepin, Mendota, and Michigan. Mysis and calcium carbonate crystals were found only in fishes caught in the depths of lakes where there was cool water which contained oxygen. Of the twenty-three classes of foods in the dietary of all the fishes studied, more than half were eaten by fishes in all the lakes.

TABLE XII

COMPARISON OF FOODS EATEN BY THE FISHES IN GREEN LAKE (1919), LAKE MENDOTA (1919), LAKE PEPIN (1920), LAKE MICHIGAN (1920), LAKE GENEVA (1920).

Foods	Green Lake	Lake Mendota	Lake Pepin	Lake Michigan	Lake Geneva	Average
Birds.....	.....	.....	.13	.....	.....	.026
Fishes.....	9.6	16.8	15.4	21.8	23.1	17.35
Immature insects.....	28.4	16.4	21.2	21.9	30.4	23.66
Adult insects.....	3.3	17.1	1.6	2	6.6	6.12
Mites.....	.4	+	.09	+	.78	.254
Crayfishes.....	6.8	6.8	7.9	7.2	4.4	6.62
Mysis.....	.3	.....	.....	.....	.....	2.26
Amphipods.....	16.5	2.9	1.7	4.2	3.9	5.84
Isopods.....	.....	.....	.....	.94	.....	.188
Cladocerans.....	7.6	9	24.7	8	18.9	13.64
Copepods.....	.1	1.6	4.9	.71	1.2	1.702
Ostracods.....	3	3.7	3.6	2.1	.52	2.584
Clams.....	4.1	+	1.9	2.1	.37	1.694
Snails.....	4.4	5	2.9	1.1	3.9	3.46
Leeches.....	.5	.6	.....	.....	.....	.22
Oligochaetes.....	6	.4	.03	2.9	1.3	2.126
Roundworms.....	+	.....	+	+	+	+
Rotifers.....	.....	.....	.12	.....	.....	.24
Sponges.....	+	+	.03	+	.....	.006
Protozoans.....	.....	+	.1	+	.....	.02
Plants.....	4.5	8.2	1.9	.61	.92	3.226
Algae.....	.2	5.2	3.8	+	.12	1.864
Bottom.....	4.5	5.5	7.5	4.4	3.6	5.10
Calcium carbonate.....	.....	.....	.....	.29	.....	.058
Unknown.....	.4	.1	.5	.9	.25	.43

The classes of foods grouped under the lake where they were found in largest amount are as follows:

Pepin—birds, crayfishes, cladocerans, copepods, rotifers, sponges, protozoans, bottom sediment.

Mendota—adult insects, ostracods, snails, leeches, plants, algae.

Green Lake—amphipods, clams, oligochaetes.

Lake Geneva—fishes, immature insects, mites.

Lake Michigan—Mysis, isopods, calcium carbonate crystals.

Some foods were eaten in greater quantity in lakes that were most like rivers: birds, cladocerans, copepods, rotifers, sponges, protozoans, bottom sediment. Other foods were found less often where conditions were like rivers and increased where typical lacustrine conditions prevailed: fishes, Mysis, amphipods, isopods, oligochaetes, calcium carbonate crystals. Some foods eaten in about the same amount in all types of lakes: immature

insects, crayfishes, ostracods, clams. Adult insects were eaten in great quantity in Lake Mendota, which has very rich stores of food and varied shores. Three foods apparently depend upon the abundance of aquatic vegetation present: snails, flowering plants and algae.

According to the average amount consumed in all the lakes, the foods rank in the following order (Table XII): immature insects, fishes, cladocerans, crayfishes, adult insects, amphipods, bottom sediment, snails, plants, ostracods, Mysis, oligochaetes, algae, copepods, clams, mites, rotifers, leeches, calcium carbonate crystals, protozoans, sponges, roundworms. The first three items in this list constitute more than half of the food of the fishes in the five lakes under consideration.

The fishes which are shown to take large quantities of particular foods are as follows (Tables IX to XII, and Pearse, 1921):

Birds—speckled bullhead.

Fishes—yellow bullhead, lake trout, pickerel, long-nosed gar, lawyer, sauger, wall-eyed pike; and to a certain extent white bass, large- and smallmouth black bass.

Immature insects—pirate perch, Johnny darter, pumpkinseed, Iowa darter, short-headed red-horse, silversides, log-perch, skip-jack.

Adult insects—smallmouth black bass.

Crayfishes—eel, black bullhead (Lake Michigan), yellow bullhead, rock bass, duck-billed gar.

Amphipods—common sucker, whitefish, cisco (Lake Mendota, Green Lake)

Mysis—ciscoes (Lake Michigan), deep-water cottids.

Cladocerans—mooneye, red-mouth buffalo, two shiners (*Notropis jejunus* and *N. hudsonius*), spoonbill, crappies, hackleback sturgeon, tadpole cat.

Ostracods—smallmouth buffalo.

Clams—sheepshead.

Snails—pumpkinseed.

Plants—bluegill.

Algae—channel cat, gizzard shad.

Bottom sediment—two quillbacks (*Carpoides carpio*, *C. thompsoni*), gizzard shad, white-nosed sucker, and to some extent the blunt-nosed minnow.

A number of species of fishes did not show a marked preference for any particular food or distributed their feeding activities among several foods. The sheepshead ate immature insects, clams, and cladocerans. The speckled bullhead had a varied diet. The common sucker had, in different lakes, eaten considerable amounts of snails, clams, algae, amphipods and

copepods. The carp is an omnivorous feeder. Other fishes which show a rather varied diet are top minnow, bluegill, the two species of black bass, a shiner (*Notropis heterodon*), bream, and blunt-nosed minnow. The yellow perch relies chiefly on three common foods: immature insects, cladocerans, fishes.

There were several species which showed considerable ability to change their foods with different environments. It is hard to understand why the rock bass ate many crayfishes in all the lakes except Geneva, where crayfishes were most abundant (Tables II-V). In Lake Michigan the black bullhead ate largely of crayfishes, but in Pepin took a variety of foods. The yellow bullhead ate fishes or crayfishes. The ciscoes in Lake Michigan ate Mysis and Pontoporeia, but in Lake Geneva, where Mysis probably does not occur, they were filled with cladocerans, and in Lake Mendota had partaken largely of immature insects. The shiners of the genus *Notropis* showed differences in food habits in different lakes. In Lake Pepin they fed largely on cladocerans, but in Green, Mendota, and Michigan had turned to immature insects. The white bass in Lake Pepin ate cladocerans and fishes, but in Lake Mendota fed on adult insects.

GENERAL DISCUSSION OF THE FOOD AND DISTRIBUTION OF FISHES IN WISCONSIN LAKES

As an environment for fishes a lake possesses certain qualities which differ from those in a swamp or a river. Perhaps the chief characteristic of a lake, as compared with other aquatic habitats, is stability. It is comparatively quiet; its water level does not fluctuate much; if it has sufficient depth, its water stratifies and the deeper parts are always cool; its supplies of food are about the same each year; its seasonal cycles occur with regularity. A lake is dependable. A swamp or a river cannot be relied upon—temperatures vary to extremes with seasons and weather; floods or droughts change the whole environment, affect the food supplies, and often interfere with reproduction. The fishes in a lake have a limited range, but enjoy the advantages of a stable environment.

The observations discussed in this paper indicate that as the conditions in lakes approach those in swamps the number of fishes per unit of area becomes larger. In other words a shallow, vegetation-filled lake contains more fishes in proportion to its area than a larger lake with fewer aquatic plants. The reason for this is probably that the great stores of foods occurring in swamps are associated in these lakes with some of the stability inherent in lake habitats. Yet small, shallow lakes are not the optimum habitats for lake fishes. The species which flourish in them (crappie, sunfishes, dogfish, bullheads, black basses, etc.) are those which frequent aquatic vegetation. The true lake fishes (ciscoes, trout, lawyers, yellow perch, etc.) are usually absent, and when present, though sometimes abundant, never attain great size.

The observations also indicate that rivers, at least in summer, contain fewer fishes per unit of area than lakes. For fishes a river is a highway and a refuge. It gives access to the stores of food in swamps and lakes, and in winter furnishes an environment which is fairly stable. However, a river is not capable of producing much fish food within itself. The food resources available to lake fishes in the bottom mud cannot occur in quantity in rivers because the bottom is continually changing.

The most abundant bottom fish in Lake Pepin, the hackleback, secured only one third of its food from the bottom; the remainder consisted largely of plankton. That the river itself is not an important habitat for fishes is also indicated by the fact that Lake Pepin is the only lake among those studied in which a large number of fishes were caught in the shallowest zone. The fishes, except in winter when larger fishes eat little or nothing (Pearse and Achtenberg, 1920, p. 313), are largely in shallow water, not in the lake itself.

There are certain fishes that belong ecologically to rivers, small streams, swamps, or lakes. Some species of fishes are restricted to certain habitats in particular communities; others range through a wide variety of habitats and communities, but there is of course no fish that is not limited by the factors in its environment. The more limited a fish is, the more restricted is its range and the fewer it is in numbers. If all the lakes studied are considered together, the most abundant species are those which are least limited and are therefore able to take advantage of the greatest number of chances for growth, survival, and reproduction. Darters are most abundant in streams and ciscoes in the depths of lakes; perch and carp are found in a variety of habitats. The common eel of northern South America has the greatest ecological range of any fish studied by the writer (1920)—from the depths of lakes to the ditches and drain pipes in cities.

In temperate regions there are three types of lakes, the classification depending primarily on the temperatures and dissolved gases (Birge and Juday, 1911): (1) shallow lakes which have a rather uniform temperature from top to bottom at all seasons, (2) deep lakes which are at times thermally stratified but which contain oxygen throughout at all seasons, (3) deep lakes which are thermally stratified and in which oxygen is absent from the deeper, cooler parts during certain seasons. In the following paragraphs some of the important factors which limit the distribution of fishes are discussed.

Shores vary in their nature and the different types are important for fishes. Boulders and rocks are associated with currents and wave action; mud, with quiet water; and sand with intermediate conditions. The rock bass, fantail darter, and miller's thumb are found on rocky shores. Among the lakes dis-

cussed in this paper, Lake Geneva has the most strikingly rocky shores. The rock bass is most abundant in this lake as is its favorite food—the crayfish—which commonly hides among stones alongshore.

Transparency of water. In all but one of the lakes more species of fishes were found in the first five meters below the surface than in any deeper zone. In Lake Pepin a comparatively large number of fishes was caught per hour in the upper five meter zone. In the most transparent lake studied (Table V) the preponderance of the fishes in the second five meters below the surface was very striking. The more transparent the water in a lake is, the deeper can the aquatic vegetation migrate. Most shore fishes are associated with the zones where water plants are found.

Depth. The depth of a lake is important in many ways. The summer temperature may be gradually less at greater depths; the pressure increases downward; the dissolved gases are influenced by the stagnation due to thermal stratification. Though more species are usually found in the shallower parts of lakes, there are some true deep-water fishes which are not found except in cool depths where the pressure is great: certain ciscoes, lawyer, etc. Some fishes, though they commonly feed on the bottom and are found in lakes where there is abundant bottom food and oxygen at all depths, are perhaps kept from feeding on the bottom by some factor associated with depth. Apparently the perch in Green Lake and Lake Michigan would gain much by feeding on the bottom everywhere, as they do in other lakes which are not so deep, but they do not do so.

Vegetation. Many of the shore fishes spend most of their lives in or near the shore vegetation. The bluegill is caught in lakes much more than the pumpkinseed, which has similar habits—apparently because it feeds more from the surface. The pumpkinseed is always found among vegetation and the writer has never seen it in an “open” lake. Vegetation supplies food, directly and indirectly, and furnishes shelter for fishes. Kofoid (1903, p. 496), in speaking of lakes has stated that, “whenever the depth of the water, the currents, the winds, or other factors prevent the development of a submerged aquatic flora—the entire production of the lake takes the form of plankton and, in turn, of those larger species, insect larvae, molluscs, and fish,

which are directly or indirectly supported by it." It is doubtless true that there is a reciprocal relation between the larger vegetation and the phyto-plankton, but Kofoid ignores the bottom fauna and detritus feeders which constitute an important part of the food resources in a lake. Furthermore, some shallow lakes (Wingra) have much aquatic vegetation and much plankton.

Bottom. The soft bottom mud in lakes may support an abundant fauna of insect larvae, Sphaeridae, annelids, and protozoans. These animals live on the remains of plankton animals, the organic ooze, fragments of leaves, sticks, and other organic materials from land. Bottom mud and the animals inhabiting it are important fish foods. If the bottom is sandy fewer fishes frequent it (compare Lake Pepin and Green Lake, Tables II, VI).

Variation in height of water. Lake Pepin is the only lake studied that shows a marked variation in the height of the water. Shira (1917) has suggested that the buffalo is dependent on overflowed bottoms for spawning. In this connection the experience of Mr. W. E. Wiedner, who has operated a commercial seine in Lake Mendota for six years, is of interest. He has never seen a small buffalo, but frequently catches adults. He believes the fishes entered the lake from the Rock River years ago and, since the outlet has been dammed, find conditions unsuitable for spawning. The writer has seined extensively along the shores of Lake Mendota and has never caught a small buffalo. The overflow of the shores of lakes enables fishes to invade new feeding grounds. The writer once examined a carp from Lake Monona which had eaten bluegrass from a pasture. The bullhead mentioned in this paper as having eaten a young bird doubtless got its meal from overflowed land. Falling water often leaves fishes stranded, and many die annually.

Current. Currents are usually not important in lakes. Some fishes, like certain darters and the smallmouth black bass which frequent swift, clear streams, are also found along the rocky or sandy shores of clear lakes. In Lake Geneva there are many bass, but no darters. The absence of the latter has no apparent explanation.

Gases. In thermally stratified lakes it is important for fishes whether the deeper parts become stagnant or not. In

deep lakes which stagnate (Mendota, Geneva) the perch is the dominant deep-water fish. In those which have oxygen at all depths throughout the year (Green, Michigan), the ciscoes are the most abundant fishes in deep water.

Size of lake. The size of a lake has a direct effect on wave action along its shores. A small lake usually has much aquatic vegetation at its margins while a large lake, like Lake Michigan, has rather barren, rocky or sandy shores. The total body of water in a lake is important in connection with contamination, temperature cycles, etc. For commercial fishing on a large scale a large lake is best, because it has greater resources and will last longer before its fishes are exhausted. Such a lake is not inexhaustible, however.

Behavior. The behavior of fishes limits them to certain areas. Some species react to the stimuli that they encounter so as to remain in deep water, others respond so as to remain in or near vegetation, etc. It is important to remember that fishes choose the habitats in which they are found.

Reproduction. Fishes of course cannot persist where they are cut off from suitable conditions for breeding. Some species require rocky shoals, others vegetation, etc. If the proper environment for spawning is lacking a fish is excluded from a lake, though food may be abundant and other factors important for everyday life may be favorable.

Food. The foods of fishes in all lakes are, in order of importance, insects, plankton crustaceans, larger crustaceans, molluscs, mud, plants, and certain minor aquatic animals. The results discussed in this paper show that in a lake (Pepin) where conditions most resemble those in rivers, plankton, bottom sediment, and crayfishes are the important foods. There are fishes present with specialized food habits which feed primarily on these particular foods—mooneye, spoonbill, duck-billed gar, red-horses, quillbacks, etc. In the more isolated inland lakes, fishes, insects, molluscs, and plants are the important foods. In Lake Michigan the important fishes feed largely on the deep water crustaceans.

Civilization. The activities of man are important for lake fishes. The decrease of many species is doubtless due to the "march of civilization." Examples are the buffalo and spoonbill in Lake Pepin, the whitefish in Lake Michigan, and the ciscoes

in Lake Geneva. The present generation is awake to the importance of "conservation," but few people realize how important it is to preserve the *completeness* of the environment. The Mississippi cannot continue to furnish buttons and food fishes if the swamps along its borders are drained and used for agriculture. The ultimate value of changes which involve the elimination of great living natural resources should be carefully considered before being undertaken. Sometimes two branches of commerce help each other. The chief clam-eating fishes in Lake Pepin are the carp and sheepshead. The same two fishes are yielding the best profits to fishermen. The growth of clams for buttons is fostered by commercial seining in the Mississippi.

The productiveness of a lake depends on various combinations of the factors just considered. Lake Pepin, which has intimate association with the Mississippi River, according to the writer's catches contained the greatest number of species, but the smallest number of fishes per unit of area. The largest numbers of fishes per unit of area were found in the inland lakes with considerable vegetation and rich bottom faunas. The two deep, clear inland lakes with little vegetation and plankton both rank ahead of Lake Michigan in this respect. Lake Geneva has the most limited fauna in species.

From these facts it appears that the factors which make fishes numerous in a lake are abundant food and vegetation. But these factors, while they permit numbers to *exist*, do not necessarily allow fishes to reach their maximum degree of perfection. Lake Wingra contains more fishes than Lake Mendota per unit of area, but its lake fishes are small in size. Lake Mendota with its varied shores and greater depth offers a more favorable environment in which fishes may *develop to large size*. Lake Michigan, which is thinly populated, produces some gigantic fishes.

Lake Geneva and Green Lake present the most monotonous environments of any of the lakes studied, and, probably on that account, contain the smallest number of species. However, Lake Geneva contains the largest number of desirable game fishes (wall-eyed pike, smallmouth black bass, and pickerel) of any of the lakes. In this respect Green Lake ranks second with many pickerel and good numbers of smallmouth black bass. The clear deep lakes are apparently the most desirable

from the sportsman's point of view. Lake Geneva has been a resort for fishermen for many years, yet continues to produce considerable numbers of game fishes.

For commerical fishing a lake should produce a constant supply in considerable numbers and for a long period of time. These conditions can of course be met only in large bodies of water, and continual fishing should not be carried on in small lakes.

For the production of large numbers of fishes a lake should have much food and vegetation. To permit fishes to develop to large size a lake should offer a variety of habitats—or conditions for living. For the production of game fishes a lake should possess special features which favor the development of the species desired and exclude undesirable species. Lake Geneva, with its beautiful rocky shores, great depth, clear water, low temperatures in deeper strata, and scanty shore vegetation, is a poor place for carp but an admirable habitat for game fishes. Lake Pepin, which is a highway to all the varied habitats along the Mississippi, and Lake Michigan, with its enormous food resources in deep water, will long continue to serve the commercial fishermen. The Mississippi is not itself a particularly favorable habitat for fishes. If the swamps, lakes, and slews, which furnish the bulk of the food and variety of habitats for its fishes are destroyed or cut off from it, the fishes must decrease. Lake Michigan, while it is not inexhaustible, gives its commercial fishes a more certain tenure, because its food resources are less likely to be destroyed.

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